CHAPTER 1 INTRODUCTION

1.1 GENERAL

This draft Programmatic Environmental Impact Statement (DPEIS) for the Louisiana Coastal Area (LCA), Ecosystem Restoration Study (LCA Study) was prepared by the U.S. Army Corps of Engineers (USACE)-Mississippi Valley, New Orleans District (the District), with input provided by the Louisiana Department of Natural Resources (LDNR), and other Federal and state coastal resource agencies. The following Federal agencies are a Cooperating Agency for the LCA Study: Minerals Management Service (MMS), Natural Resources Conservation Service (NRCS), National Marine Fisheries Service (NMFS), U.S. Environmental Protection Agency (USEPA), U.S. Fish and Wildlife Service (USFWS), and the U.S. Geological Survey (USGS).

The Louisiana Coastal Plain contains one of the largest expanses of coastal wetlands in the contiguous United States, and accounts for 90 percent of the total coastal marsh loss in the Nation. The coastal wetlands, built by the deltaic processes of the Mississippi River, contain an extraordinary diversity of coastal habitats that range from narrow natural levee and beach ridges to expanses of forested swamps and freshwater, intermediate, brackish, and saline marshes. Taken as a whole, the unique habitats, with their hydrological connections to each other, upland areas, the Gulf of Mexico, and migratory routes of birds, fish, and other species, combine to place the coastal wetlands of Louisiana among the Nation's most productive and important natural assets. In human terms, these coastal wetlands have been a center for culturally diverse social development.

Louisiana's coastal wetlands and barrier island systems enhance protection of an internationally significant commercial-industrial complex from the destructive forces of storm-driven waves and tides. This complex of deep-draft ports includes the Port of South Louisiana, which handles more tonnage than any other port in the Nation, and the most active segment of the Nation's Gulf Intracoastal Waterway (GIWW) (Waterborne Commerce Statistics Center (WCSC), 2002). In 2000, Louisiana led the Nation with production of 592 million barrels of oil and condensate (including the outer continental shelf (OCS)), valued at $17 billion, and was second in the Nation in natural gas production with $1.3 billion (excluding OCS and casing head gas) (Louisiana Department of Natural Resources (LDNR, 2003).

Additionally, coastal Louisiana is home to over 2 million people, representing 46 percent of the state's population. When investments in facilities, supporting service activities, and the urban infrastructure are totaled, the capital investment in the Louisiana coastal area adds up to approximately $100 billion. Louisiana produced about $343 million of commercial marine fish landings, which includes all landings except mollusks such as clams, oysters, and scallops (NMFS, 2003). Recent data from the USFWS show expenditures on recreational fishing (trip and equipment) in Louisiana to be nearly $695 million for 2001 (USFWS, 2002).

Approximately 70 percent of all waterfowl that migrate through the United States use the Mississippi and Central flyways. With over 5 million birds wintering in Louisiana, the Louisiana coastal wetlands are a critical piece of habitat to these birds, as well as to neotropical migratory songbirds and other avian species that use them as critical stopover habitat. Additionally, coastal Louisiana provides critical nesting habitat for many species of water birds, such as the endangered brown pelican. These economic and habitat values, which are protected and supported by the coastal wetlands of Louisiana, are significant on a National level.

1.2 STUDY AUTHORITY

This study is authorized through resolutions of the U.S. House of Representatives and Senate Committees on Public Works, April 19, 1967 and October 19, 1967. These resolutions both contain the following language:

> "RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, That the Board of Engineers for Rivers and Harbors created under Section 3 of the River and Harbor Act approved June 13, 1902, be, and is hereby requested to review the reports of the Chief of Engineers on the Mermentau River and Tributaries and Gulf Intracoastal Waterway and connecting waters, Louisiana, published as Senate Document Numbered 231, Seventy-ninth Congress, on the Bayou Teche, Teche-Vermilion Waterway and Vermilion River, Louisiana, published as Senate Document Numbered 93, Seventy-seventh Congress, on the Calcasieu River salt water barrier, Louisiana, published as House Document Numbered 582, Eighty-seventh Congress, and on Bayous Terrebonne, Petit Caillou, Grand Caillou, Dularge, and connecting channels, Louisiana, and the Atchafalaya River, Morgan City to the Gulf of Mexico, published as House Document Numbered 583, Eighty-seventh Congress, and other pertinent reports including that on Bayou Lafourche and Lafourche-Jump Waterway, Louisiana, published as House Document Numbered 112, Eighty-sixth Congress, with a view to determining the advisability of improvements or modifications to existing improvements in the coastal area of Louisiana in the interest of hurricane protection, prevention of saltwater intrusion, preservation of fish and wildlife, prevention of erosion, and related water resource purposes."

Attachment 1 of the Main Report includes summaries of other pertinent coastal restoration and related water resources authorizations that may be useful for implementing coastal restoration.

1.3 STUDY PURPOSE AND SCOPE

The purpose of the LCA Study is to:

- Identify the most critical human and natural ecological needs of the coastal area;
- Present and evaluate conceptual alternatives for meeting the most critical needs;
- Identify the kinds of restoration features that could be implemented in the near-term (within 5 to 10 years) that address the most critical needs, and propose to address these needs through features that provide the highest return in net benefits per dollar of cost;
- Establish priorities among the identified near-term restoration features;

- Describe a process by which the identified priority near-term restoration features could be developed, approved, and implemented;
- Identify the key scientific uncertainties and engineering challenges facing the effort to protect and restore the ecosystem, and propose a strategy for resolving them;
- Identify, assess and, if appropriate, recommend feasibility studies that should be undertaken within the next 5 to 10 years to fully explore other potentially promising large-scale restoration concepts; and
- Present a strategy for addressing the long-term needs of coastal Louisiana restoration beyond the near-term focus of the Louisiana Coastal Area Ecosystem Restoration Plan (LCA Plan).

The goal of the LCA Plan is to reverse the current trend of degradation of the coastal ecosystem. The plan maximizes use of restoration strategies that reintroduce historical flows of river water, nutrients, and sediments to coastal wetlands and that maintain the structural integrity of the coastal ecosystem. Execution of the LCA Plan would make significant progress towards achieving and sustaining a coastal ecosystem that can support and protect the environment, economy, and culture of southern Louisiana and thus, contribute to the economy and well being of the Nation. Benefits to and effects on existing infrastructure, including navigation, hurricane protection, flood control, land transportation works, agricultural lands, and oil and gas production and distribution facilities were strongly considered in the formulation of coastal restoration plans.

The LCA Plan is based upon the extensive experience gained through the on-going Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) implementation effort, best available science and engineering, professional judgment, and other extensive experience in coastal restoration in Louisiana and beyond. The LCA Study identifies, evaluates, and recommends to decision makers an appropriate, coordinated, feasible course of action to address the identified critical water resource problems and restoration opportunities in coastal Louisiana. This report provides a complete presentation of the study process, results, and findings; indicates compliance with applicable statutes, executive orders, and policies; documents the Federal and non-Federal interest; and provides a sound and documented basis for decision makers at all levels to evaluate the request for:

- Authorization of programmatic authority for implementation of five near-term critical restoration features for which construction can begin within 5 to 10 years subject to follow-up feasibility-level decision documents;
- Authorization of a Science and Technology Program;
- Authorization of Science and Technology Program demonstration projects;
- Programmatic authority for the beneficial-use of dredged material;
- Programmatic authority to initiate studies of modification to existing water control structures;
- Standard authorization of ten near-term critical restoration features for which construction can begin within 5 to 10 years; and
- Approval of plan for assessing potentially promising large-scale and long-term restoration concepts.

The approval of the LCA Plan would initiate development of a series of feasibility-level decision documents that would provide detailed project justification, design, and implementation data. These future feasibility-level decision documents would support requests for project construction and would provide the basis for the implementation of the plan documented in this study report.

1.4 STUDY AREA DESCRIPTION

The study area, which includes Louisiana's coastal area from Mississippi to Texas, consists of two wetland-dominated ecosystems, the Deltaic Plain of the Mississippi River and the closely linked Chenier Plain, both of which are influenced by the Mississippi River. For planning purposes, the study area was divided into four subprovinces, with the Deltaic Plain comprising Subprovinces 1, 2, and most of 3, and the Chenier Plain comprising Subprovince 4 (**figure 1-1**).

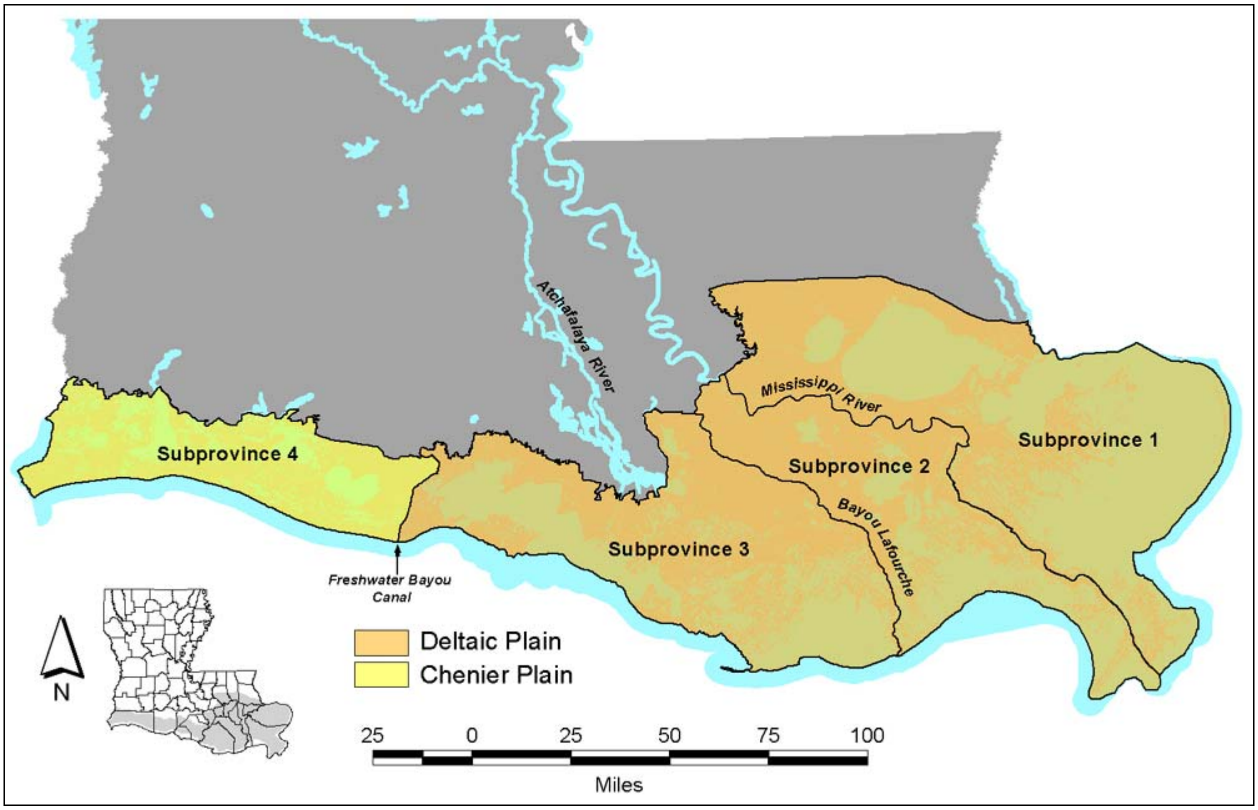

Figure1-1. LCA Study Area and Subprovinces.

Louisiana parishes included in the study area are: Ascension, Assumption, Calcasieu, Cameron, Iberia, Jefferson, Lafourche, Livingston, Orleans, Plaquemines, St. Bernard, St. Charles, St. James, St. John the Baptist, St. Martin, St. Mary, St. Tammany, Tangipahoa, Terrebonne, and Vermilion (**figure 1-2**). Subprovince 1 covers portions of Livingston, Tangipahoa, St. Tammany, St. Bernard, Orleans, St. Charles, St. John the Baptist, St. James, Ascension, Plaquemines, and Jefferson Parishes. Subprovince 2 covers all or part of Ascension, Plaquemines, Jefferson, Lafourche, St. Charles, St. James, St. John the Baptist, and Assumption Parishes. Subprovince 3 contains all or part of Lafourche, Terrebonne, Assumption, Iberville, St.

Martin, Iberia, St. Mary, and Vermilion Parishes. Subprovince 4 contains all or part of Vermilion, Cameron, and Calcasieu Parishes.

Today, the Deltaic Plain is a vast wetland area stretching from the eastern border of Louisiana to Freshwater Bayou. It is characterized by several large lakes and bays, natural levee ridges (up to 20 feet above sea level), and bottomland hardwood forests that gradually decrease in elevation to various wetland marshes. The Deltaic Plain contains numerous barrier islands and headlands, such as the Chandeleur Islands, Barataria Basin Barrier Islands, and Terrebonne Basin Barrier Islands. The Chenier Plain extends from the Teche/Vermilion bays to Louisiana's western border with Texas, and is characterized by several large lakes, marshes, cheniers, and coastal beaches.

Within the broadly delineated zones of marsh habitat types, a variety of other wetland habitats (with distinct surface features and vegetative communities) occur in association with the marshes. These include swamp and wetland forests, beach and barrier islands, upland, and other important habitats. There are also unique vegetative communities in the coastal area, such as floating marshes and maritime forests, that contribute to the extensive diversity of the coastal ecosystem and which are essential to the overall stability of the ecosystem.

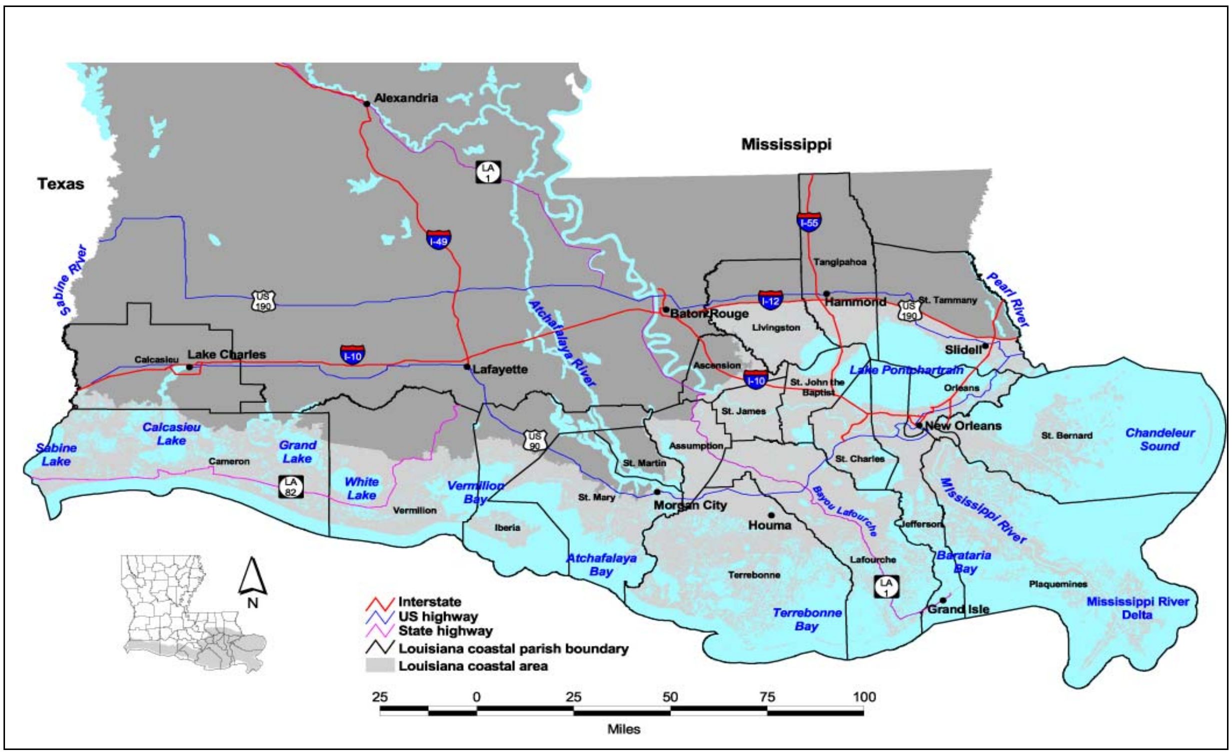

Figure 1-2. LCA Study Area Parishes, Major Water Bodies, and Highways.

Subprovince 1**:** Subprovince 1 includes the Breton Sound and portions of the Pontchartrain and Pearl hydrologic basins **(figure 1-3**). The Pontchartrain Basin, the largest in the subprovince, is about 4,200 square miles of estuarine habitat, and receives runoff from several smaller basins, including the Amite, Tickfaw, Tangipahoa, and Tchefuncte Basins. Lake Maurepas, Lake Pontchartrain, and Lake Borgne are the major lakes found in the basin. Pass Manchac and North

Pass connect Lake Maurepas with Lake Pontchartrain, while Chef Menteur Pass and the Rigolets connect Lake Pontchartrain with Lake Borgne and Mississippi Sound.

The Breton Sound Basin includes Lakes Lery and Big Mar, which are the largest water bodies in the northern part of the basin. Black Bay, California Bay, and Breton Sound are located in the southern part of the basin. Breton Sound is the largest water body in the subprovince. Currently, the Caernarvon Freshwater Diversion project introduces freshwater, sediment, and nutrients into the Terre aux Boeufs of the upper Breton Sound marshes.

Major navigational channels include the Mississippi River Gulf Outlet (MRGO), GIWW, and the Mississippi River. The MRGO and the GIWW introduce and/or compound marine influences in many of the coastal wetlands and water bodies within the subprovince.

The lower portion of the subprovince contains many tidal channels. This area contains great habitat diversity, including extensive bottomland hardwood forests adjacent to the Mississippi River. Cypress-tupelo swamp covers the upper portion of the subprovince. South of the swamps, marshes extend to the Gulf of Mexico and the Mississippi Delta. Fresh marshes are found in the north, with a band of intermediate marsh lying southward. Portions of the subprovince contain brackish marshes, and saline marshes fringe the Gulf of Mexico and Breton Sound.

The 46-mile long Chandeleur barrier island system is the oldest barrier island arc in the Deltaic Plain and encloses Breton and Chandeleur Sounds in St. Bernard and Plaquemines Parishes.

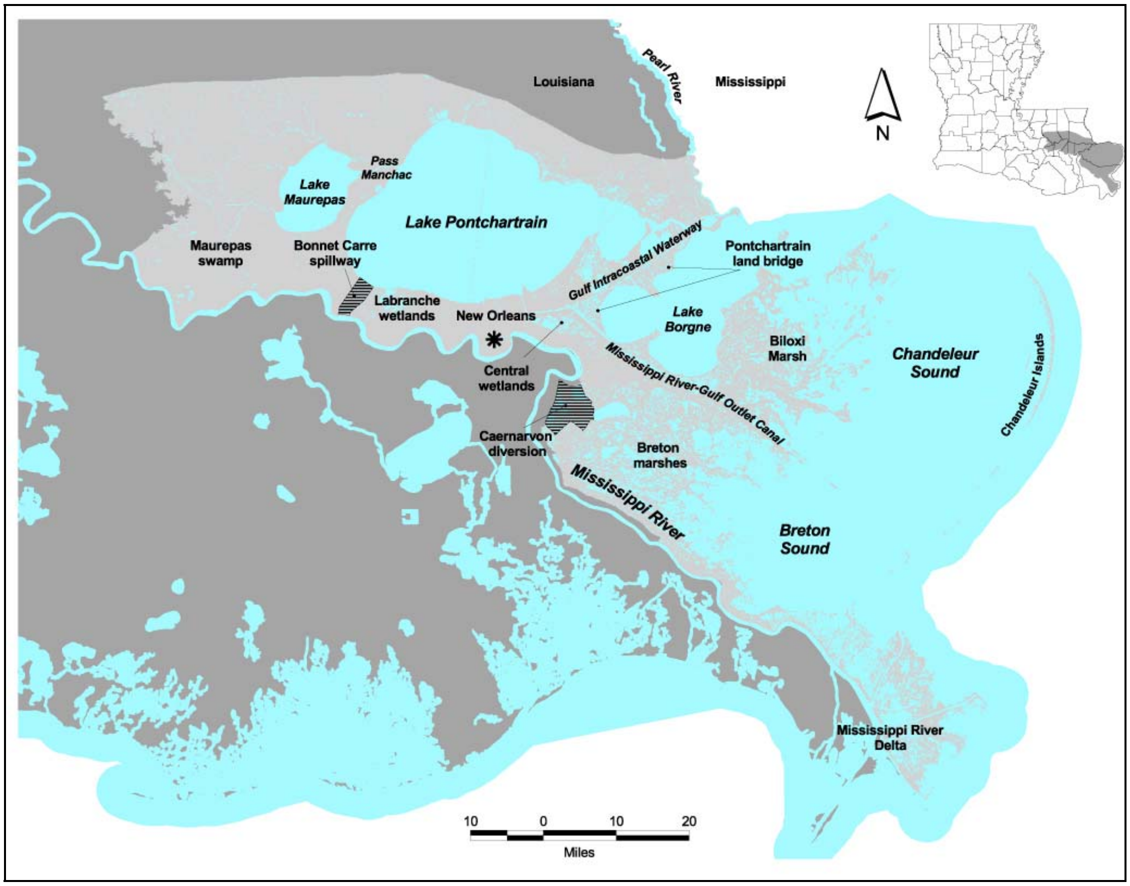

Figure 1-3. Major hydrologic features of Subprovince 1.

Subprovince 2: Subprovince 2 is defined by the hydrologic boundary of the Barataria Basin, which is approximately 2,446 square miles (**figure 1-4**). This subprovince extends from the Mississippi River on the north and east, to Bayou Lafourche on the west, and the Gulf of Mexico on the south. The basin contains four major lakes; Lake Salvador, Lake Cataouatche, Little Lake, and Lac Des Allemands. The basin is separated from the gulf by a chain of barrier islands (Plaquemines and Bayou Lafourche barrier systems) that serve as a natural barrier to storm events and reduce marine influences on interior wetlands within the basin.

Currently, the Davis Pond Freshwater Diversion project directs Mississippi River water into the upper portion of the basin's wetlands. The primary purpose of the Davis Pond project has been to maintain salinity gradients in the central portion of the Barataria Basin. Prior to construction of Davis Pond, a majority of wetlands in the subprovince were hydrologically isolated from riverine influences of the Mississippi River.

Major navigational channels in the subprovince include the Mississippi River, Barataria Bay Waterway, and GIWW. Barataria Bay Waterway and the GIWW introduce and/or compound marine influences in many of the interior coastal wetlands and water bodies within the subprovince. Subprovince 2 contains great habitat diversity, including extensive bottomland hardwood forests adjacent to the Mississippi River and Bayou Lafourche. Cypress-tupelo swamps cover the upper Barataria Basin. South of these swamps, fresh, intermediate, brackish, and saline marsh extend to the Gulf of Mexico.

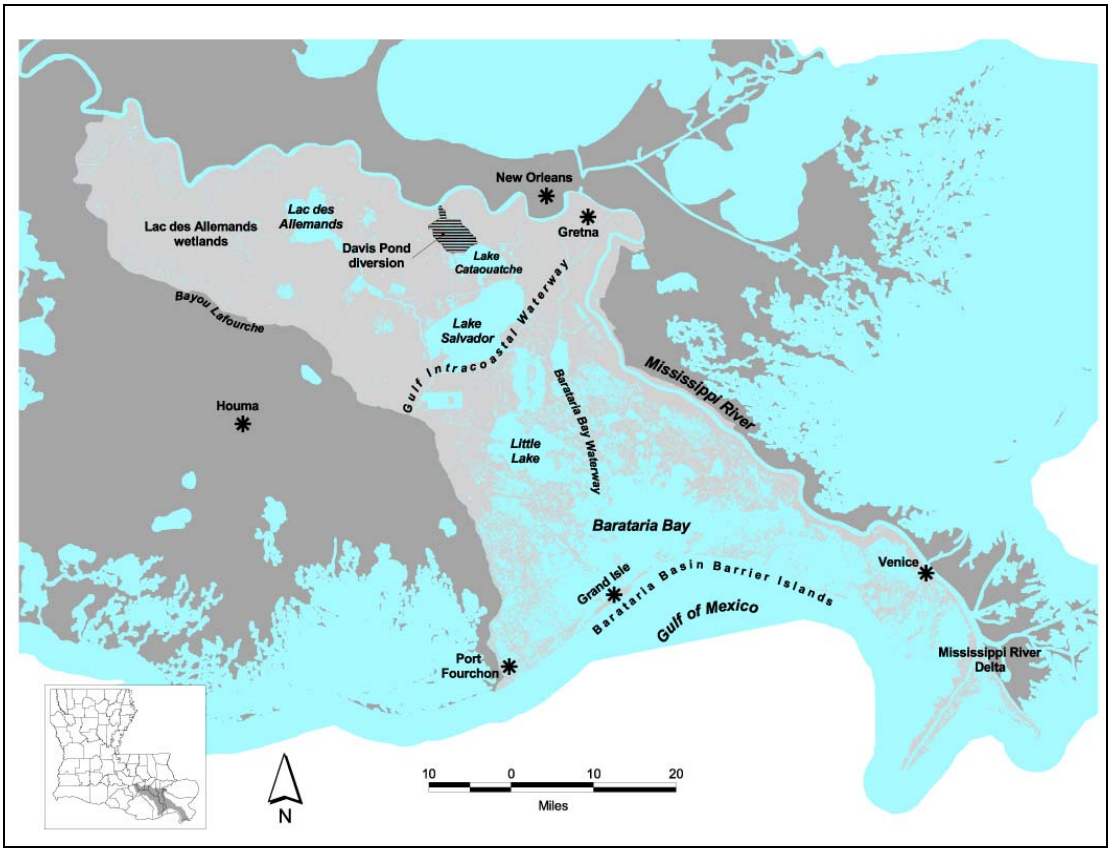

Figure 1-4. Major Hydrologic Features of Subprovince 2.

Subprovince 3: The geographic boundaries of Subprovince 3 are Bayou Lafourche on the east, Freshwater Bayou Navigation Channel on the west, and the Bayou Teche natural ridge on the north (**figure 1-5**). Hydrologic basins include Terrebonne, Atchafalaya and Teche/Vermilion. The Teche/Vermilion Basin has a drainage area of 3,040 square miles. The Atchafalaya Basin is part of the MR&T flood control system and has a drainage area of approximately 1,800 square miles. According to information presented in the Mississippi River & Tributaries, Atchafalaya Basin, Louisiana – Lower Atchafalaya Basin Reevaluation (LABR) Study, the Terrebonne Basin drainage area is approximately 1,455 square miles in size. Major waterways include the Houma Navigation Canal; the GIWW; and Chene, Boeuf and Black. The Terrebonne Basin contains barrier islands, forested wetlands and large lakes. Portions of the Terrebonne basin also contain large areas of fresh floating marsh, as well as fresh, brackish, intermediate and saline marsh. The Atchafalaya includes fresh marshes and swamps to the north and the Atchafalaya Bay to the south with two active deltas, Atchafalaya and Wax Lake Outlet. The Teche-Vermilion Basin extends from Point Chevreuil to Freshwater Bayou Canal and includes East and West Cote Blanche Bays, Vermilion Bay, and the surrounding marshes.

The Atchafalaya River, a distributary of the Mississippi River, supports delta building and wetland creation at the Wax Lake Outlet and at the mouth of the Lower Atchafalaya River. In addition, the Lower Atchafalaya River nourishes the wetlands in the Teche/Vermilion Basin, located in the western portion of the subprovince. Wetland communities immediately adjacent to and west of the Lower Atchafalaya River are some of the healthiest wetlands in the LCA, fueled by the inputs of sediments and nutrients from the Atchafalaya River.

The wetland communities within the western portions of the Terrebonne Basin are hydrologically influenced by the Lower Atchafalaya River and have a relatively low rate of land loss.

It is important to note that a majority of the sediment and freshwater that supports the active deltas in the Lower Atchafalaya River Basin pass through the Upper Atchafalaya River Basin, which is not within the LCA Study area. In essence, the upper basin acts as a large conveyance system and reservoir for freshwater and sediment material that eventually fuels delta building at the Wax Lake Outlet and the mouth of the Lower Atchafalaya River. While delivery of sediment material is necessary to sustain and, if possible, augment land building processes in the LCA Study area, the continued accumulation of sediment affects the hydrology of the upper basin, and adversely impacts its bottomland hardwood wetland communities.

Barrier islands separating the coast from the gulf include the Timbalier and Isles Dernieres barrier systems. These systems provide protection to interior areas by reducing marine influences, such as wave action and saltwater intrusion.

Major navigation channels in the subprovince are the Atchafalaya River; Atchafalaya Rivers Chene, Boeuf and Black; Atchafalaya Basin Main Channel; Wax Lake Outlet; Houma Navigation Canal; and Lower Atchafalaya River (South of Morgan City). Houma Navigation Canal, and Atchafalaya Rivers Chene, Boeuf and Black introduce and/or compounds marine influences in many of the interior coastal wetlands and water bodies within the subprovince.

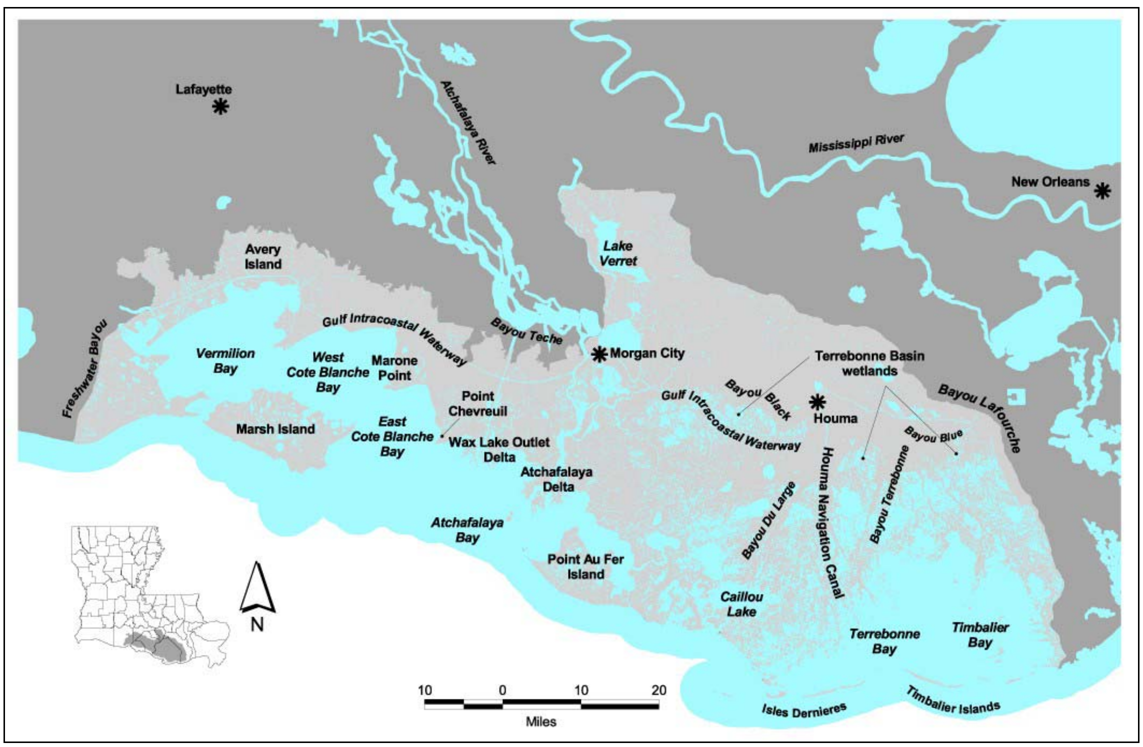

Figure 1-5. Major Hydrologic Features of Subprovince 3..

Subprovince 4: In contrast to the Deltaic Plain, the Chenier Plain formed to the west of the Mississippi River, away from active deltaic growth. The Chenier Plain extends from Freshwater Bayou, Louisiana to Sabine Pass, Texas (**figure 1-6**). Chenier Plain development is the result of the interplay of three coastal plain rivers, cycles of Mississippi River Delta development, and marine processes. Historically, cheniers acted as hydrologic barriers between the coastal salt marshes south of the cheniers and the inland fresh marshes and lakes to the north of the cheniers.

Two major hydrologic basins occur in the Chenier Plain, the Mermentau Basin and the Calcasieu/Sabine Basin. The Mermentau River is the primary freshwater supply for the Mermentau Basin, which has a drainage area of approximately 3,820 square miles. Hydrologic connectivity in some areas of the Chenier Plain, particularly within the Mermentau Basin, has been disrupted by several activities, including: the creation of dredge material banks from oil and gas canal dredging; the presence of east-west canals, such as the GIWW; and the operation of water control structures, such as the Calcasieu and Leland Bowman locks on the GIWW, the Freshwater Bayou Canal Lock, the Schooner Bayou Control Structure, and the Catfish Point Control Structure. These water control structures enable portions of the Mermentau Basin to be operated as a freshwater reservoir for agriculture, primarily rice and crawfish.

The Calcasieu/Sabine Basin is a shallow coastal wetland system with freshwater input at the north end and a north-south circulation pattern through Calcasieu and Sabine Lakes. Some east-west water movement occurs along the GIWW and interior marsh canals. Both lakes are connected to important deep-draft shipping corridors and are also used for recreational purposes. As in the Mermentau Basin, managed wetlands are a significant feature of the area, with structures in the Cameron-Creole Watershed, the Sabine National Wildlife Refuge (NWR), and privately owned lands.

Other wetland communities have become "compartmentalized" and, in effect, hydrologically isolated through the creation of dredge material banks, roads and highways, and flood protection levees, all of which can restrict water flows into or out of the area. In addition, during hurricanes and severe tropical storms, waters have surged into these compartmentalized areas and have become trapped, thereby resulting in widespread damage and loss of the marshes. Furthermore, during some extreme weather events, such as tropical storms, wetlands that are compartmentalized and/or subject to extremely slow drainage, can be particularly vulnerable to high precipitation levels, which can carpet wetlands with inches of water. In such cases, the typical result has been "ponding" of water over the wetlands. Excessive ponding over an extended duration of time in certain types of wetland habitats can kill the vegetative communities and result in the eventual loss of the wetland (conversion to open water).

In the Calcasieu drainage basin, the drainage area north of the point where the river crosses the GIWW is 3,235 square miles. The Calcasieu River flows through three small lakes before flowing into Calcasieu Lake near the coast. The Sabine drainage basin has a drainage area of 9,760 square miles. The headwaters start in northeastern Texas and the river runs about 150 miles before it meets the Louisiana-Texas state line, then runs to the gulf. Sabine Lake is a major hydrologic features of the Sabine Basin.

The Sabine/Neches Waterway, Calcasieu River Navigation Channel, GIWW, Mermentau Ship Channel, and Freshwater Bayou Canal are navigational channels in the Chenier Plain that influence the hydrology within the subprovince, primarily by increasing marine influences (saltwater intrusion, wave energies) into freshwater and other interior marshes.

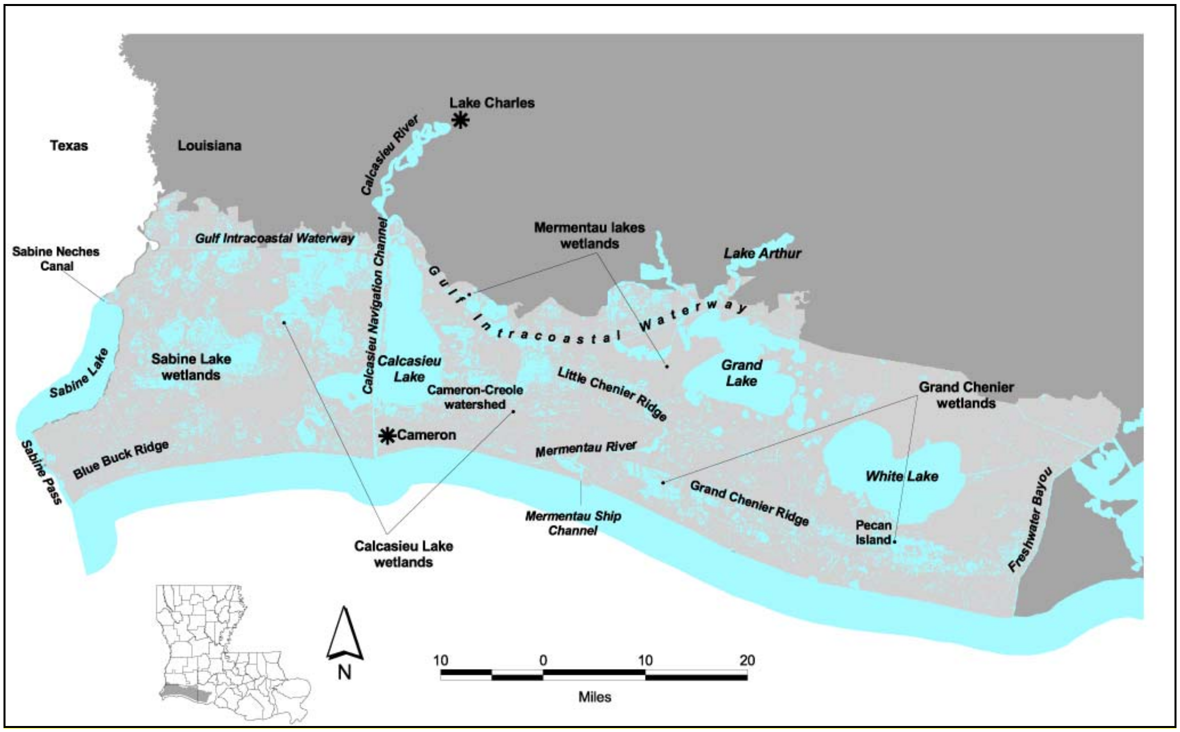

Figure 1-6. Major Hydrologic Features of Subprovince 4.

1.5 THE PROBLEM

1.5.1 Disrupting Coastal System Processes

The natural processes of subsidence, saltwater intrusion, and erosion of wetlands, combined with human effects, have caused significant adverse impacts to the LCA, including increased rates of wetland loss and ecosystem degradation. Without action, Louisiana's healthy and highly productive coastal ecosystem, composed of diverse habitats and wildlife, is not sustainable. Construction of levees along the Mississippi River has cut the coastal ecosystem off from a primary source of sediments and nutrients and hindered the wetlands' ability to maintain their elevation in the face of sea level change and subsidence. This accompanying reduction of freshwater input has enabled saltwater to intrude into more sensitive freshwater habitats. Confinement of the Mississippi River to a channel has also resulted in the bed sediment load of the river being deposited in progressively deeper waters of the Gulf of Mexico; from these locations the sediments cannot efficiently nourish the coastal barrier shorelines. These shorelines are starved for sediments and are retreating. Infrastructure constructed for access into and across the wetlands has modified the hydrology of the coastal zone, thus facilitating and accelerating saltwater intrusion and conversion of wetlands to open water. In addition, there has been a decline in the measured sediment load delivered by the Mississippi River from the rest of the drainage basin in the last 50 years.

These alterations have impacted the natural sustainability and quality of the Louisiana coastal ecosystem. This loss of sustainability has manifested itself as accelerated land loss. If recent loss rates continue into the future, even taking into account current restoration efforts, coastal Louisiana is projected to lose an additional 328,000 acres of coastal marshes, swamps, and barrier islands by the year 2050. Today, the high biological productivity of the coastal wetlands, most visibly expressed in abundant waterfowl and commercial and recreational fishery resources, masks the potential for a downward trend in biological productivity and coastal ecosystem health. The best available science on deltaic processes illustrates that biological productivity is highest during periods of wetland conversion and degradation, and that the current level of high biological productivity is unsustainable. Unless the trend of accelerated land loss is reversed, the health and productivity of the coastal ecosystem cannot be sustained.

The loss of wetlands could result in ecosystem conversion to open water by placing the following ecosystem functions at risk:

- Vegetation stability;
- Contribution from decomposing organic material;
- Protection against substrate erosion;
- Water quality improvement;
- Important nursery habitat;
- North American Central Flyway waterfowl wintering habitat; and
- Resting and feeding areas for neotropical migrants.

The abundance and diversity of aquatic and terrestrial habitat types affects the biological productivity of the fish and wildlife resources in the estuarine-marsh complex. Measurement of the relationship between habitat and productivity of all resources is difficult and can best be discussed primarily in qualitative terms; that is, a beneficial or an adverse change in environmental conditions is followed by a corresponding change in productivity. However, the relationship of marsh vegetation to the productivity of the commercial fish and wildlife resources has been documented. Biologists generally agree that habitat reduction would be accompanied by diminished harvests (Craig et al., 1979). Shrimp and menhaden yields have been correlated directly to the area of intertidal wetlands (Turner, 1979). Neotropical and other migratory avian species have been shown to depend on habitats that are in need of restoration and management in the coastal area (Barrow et al., 2000; Helmers, 1992).

Land loss and ecosystem degradation also threaten the continued productivity of Louisiana's coastal ecosystems, the economic viability of its industries, and the safety of its residents. The following valuable social and economic resources could be impacted:

- Commercial harvest of fishery resources;

- Oil and gas production;
- Petrochemical industries;
- Recreational saltwater and freshwater fisheries;
- Ecotourism;
- Strategic petroleum reserve storage sites;
- Flood control, including hurricane storm surge buffers;
- Navigation corridors and port facilities for commerce and national defense; and
- Actual and intangible value of land settled 300 years ago and passed down through generations.

1.5.2 Causes of Wetland Loss

In preparation for subsequent discussions of existing and future without-project conditions, a summary of the major factors that contribute to coastal land loss and ecosystem degradation in Louisiana is necessary. While many studies have been conducted to identify the major contributing factors (e.g., Boesch et al., 1994; Turner, 1997; Penland et al., 2000), most studies agree that land loss and the degradation of the coastal ecosystem are the result of both natural and human induced factors, which interact to produce conditions where wetland vegetation can no longer survive and where wetlands are lost. Establishing the relative contribution of natural and human-induced factors is difficult. In many cases, the changes in hydrologic and ecologic processes manifest gradually over decades and in large areas, while other effects occur over single days and impact relatively localized areas. For barrier shorelines, complex interactions among storm events, longshore sediment supply, coastal structures, and inlet dynamics contribute to the erosion and migration of beaches, islands, and cheniers.

The measurable increase in coastal land loss in the mid to late 20th century can be linked to human activities that have fundamentally altered the deltaic processes of the coast and limited their ability to rebuild and sustain it. In the Chenier Plain, human activities have fundamentally altered the hydrology of the area, which has impacted the long-term sustainability of the coastal ecosystems. Because of the magnitude and variety of these human-induced changes, and their interaction with natural landscape processes, all of the factors contributing to coastal land loss and ecosystem degradation must be viewed together to fully understand how Louisiana's coastal ecosystem shifted from the historical condition of net land gain to the current condition of accelerated net land loss.

1.5.2.1 Natural Factors Influencing Coastal Land Loss and Ecosystem Degradation

Geologic faulting, compaction of muddy and organic sediments, river floods, global sea level change, wave erosion, and tropical storm events have shaped the coastal Louisiana landscape for thousands of years (Kulp, 2000; Reed, 1995). Over millennia, sea level change and subsidence were offset by delta building in the Deltaic Plain and mudstream accretion in the Chenier Plain. Erosion of barrier shorelines and disruption of fragile organic marshes by tropical storm events resulted in land loss, but also contributed to habitat and wildlife diversity. There is little direct evidence that any of these natural processes changed in the mid-late 20th century. The following is a brief summary of the natural factors contributing to land loss.

Most of the land in coastal Louisiana was built by deltas of the Mississippi River or by Mississippi River sediment entering the coastal mudstream. Barrier islands and sandy shorelines developed as waves and coastal currents eroded and reworked river sediments, sorting out the sands and shelly material and building beaches and barrier islands. Maintaining the landscape involved these and other processes. For the marshes and swamps of coastal Louisiana soil building processes are vital. Natural processes of sediment compaction and gradual sea-level rise can submerge marsh plants and swamp forests unless soil builds up to compensate and keep the elevation high enough for plants and trees to survive. Processes contributing to soil building include sediment deposition, from rivers or by tides and storms, and the accumulation of organic material in the soil, mainly plant roots. Healthy plant growth and active sediment deposition are thus essential to the coastal ecosystem. For barrier shorelines, natural flows of sediment along shore, over islands and around inlets are also essential to maintain their habitat value. In addition, estuaries in general, and coastal wetlands in particular, tends to produce an excess of organic material, some of which is exported seaward where it represents a major energetic pathway and supports coastal fisheries (Day et al., 1989). This is known as the "outwelling hypothesis" (Odum 1980), and has been used as rationale for preserving estuaries, for it has been proven that estuaries are important in supplying food to coastal fish.

1.5.2.1.1 *Deltaic Geomorphology*

"Delta switching"--successive periods of delta growth and delta degradation--is responsible for constructing the Louisiana coastal plain over the last 7,000 years. The deltaic cycle is controlled by this switching and is characterized by a fluvial dominated regressive phase (delta building) and a marine-dominated transgressive phase (delta degradation). Ultimately, many areas of the Louisiana coast suffer from a lack of the abundant fresh water and sediment found in the Mississippi River. Since the river is no longer free to alter its course and leave its banks to inundate vast coastal areas, the effects of natural and human forces that promote wetland deterioration are compounded. In this respect, the relationship between the Mississippi River and the problems facing coastal wetlands is not limited to the river's delta, but extends across the entire Louisiana coast.

Land building and sustenance within the Mississippi River Deltaic Plain also occurred when floodwaters would overflow the riverbanks, or when river water would exit the main channel and travel through natural outlets, or distributaries, of the main river. In addition, floodwaters would periodically burst through weak points in the natural levees along the riverbank to create crevasses. Oftentimes, these floods deposited enormous amounts of sediments and were integral to land-building processes in the Deltaic Plain. Historical records indicate that major flooding events have created crevasses at 23 locations along the river in the Deltaic Plain (**figure 1-7**).

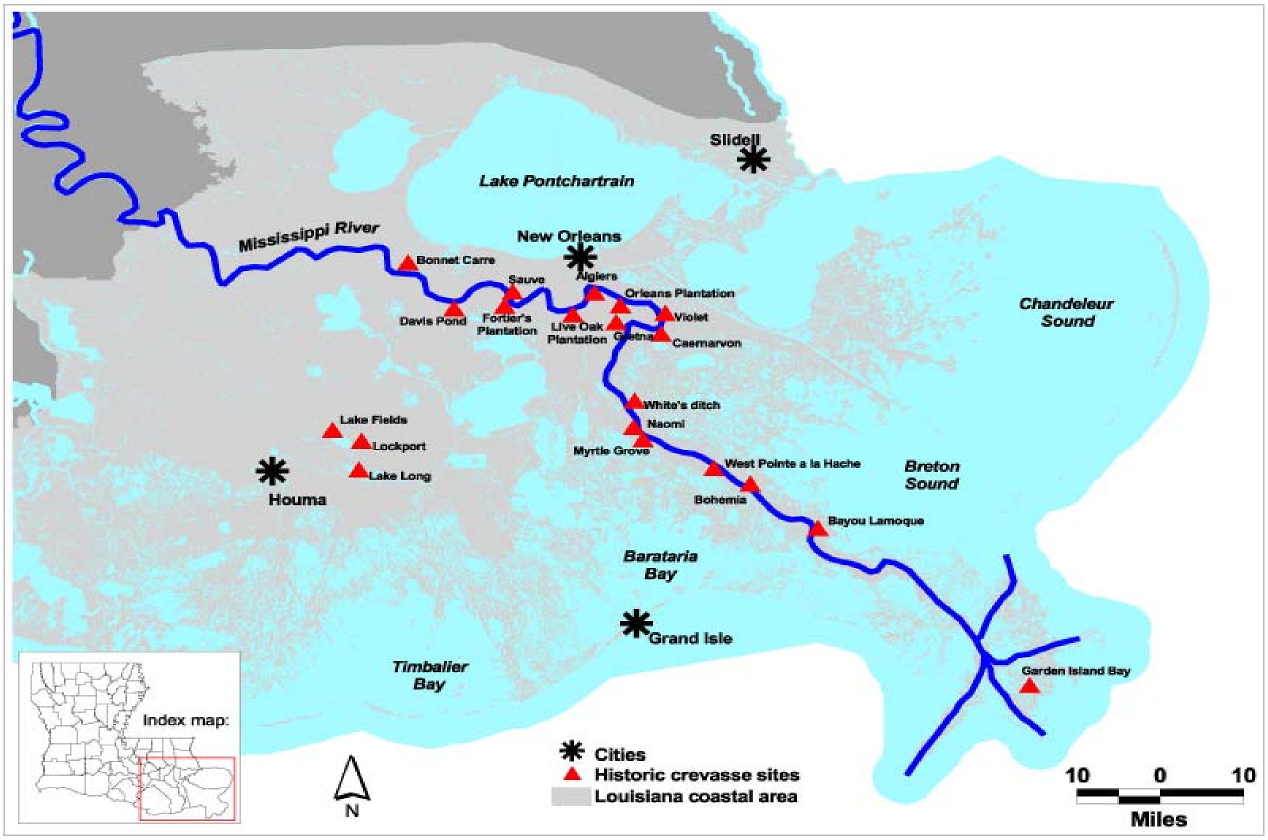

Figure 1-7. Locations of historic crevasses along the Mississippi River in the Deltaic Plain *(adapted from Colten 2001).*

1.5.2.1.2 *Loss Of Coastal Geomorphology*

The interior geomorphologic structure of the estuary is also degraded. As the structural framework of the estuary is weakened and removed, the rate at which other degenerative processes work is increased. These protective elements of the estuarine framework are critical to the stability of the system as a whole.

Barrier islands are another element of the geomorphic framework of the estuary. Longshore transport is one of the major causes of barrier shoreline erosion. The transport process removes sediment from the shoreline without a source to replace it. This causes erosional shadows downdrift of features, which include deep natural passes, navigation channels, jetties, and breakwaters. As a result, the shorelines not only transgress, but the decrease in sediment volume causes the dunes to decrease in height as well.

In addition, as the area of open water within the estuary increases, the volume of tidal exchange increases. The increase in volumetric flow of water in and out of the estuary continually increases the efficiency of sediment removal from the system. In addition, this increase in volumetric exchanges through the tidal passes scours the bottoms of the passes to accommodate the increased flow. The increased velocities and water depths transport sediments that enter the pass offshore, where they are lost to the coastal system. The result is a net reduction in the amount of sediment available for natural coastal processes.

This set of processes demonstrates the need to restore sediment input not only to the barrier island systems, but to the interior estuarine system as well. The restoration and stabilization of major geomorphologic features within the estuary, coupled with the introduction of sediments to reestablish wetland acreage, can also increase stability in the barrier islands associated with that estuary.

1.5.2.1.3 *Barrier Island Degradation*

Barrier island degradation is a natural process and represents the latter phase of the deltaic process. Marine influences, particularly those associated with tropical storm events, gradually erode and rework the structure of the islands until they eventually disappear. While the acreage amounts associated with the loss of barrier islands may not contribute significantly to the total acreage of land loss in the study area, their disappearance can result in significant and profound impacts on coastal land loss and ecosystem sustainability. Barrier islands serve as natural storm protective buffers and provide protection to Louisiana’s coastal wetlands, bays, and estuaries, by reducing wave energies at the margins of coastal wetlands, thereby limiting erosion. In addition, barrier islands limit storm surge heights and retard saltwater intrusion. The historic rates of land loss for Louisiana's barrier islands are varied, and can average as high as 50 acres per year, over several decades. Hurricane events can push the rate of land loss to surpass 300 acres per year. For example, the Isles Dernieres have decreased in acreage from approximately 9,000 acres in the late 1880s to approximately 1,000 acres by 2000 (see appendix D Louisiana Gulf Shoreline Restoration Report).

1.5.2.1.4 *Sediment Reduction/Vertical Accretion Deficit*

Vertical accretion of wetland soils depends on soil formation from sedimentary material of two types: mineral sand, silts, and clays brought in by river water, floodwaters, or winds; and living and dead organic matter produced locally by plants. In Louisiana, organic matter accumulation is frequently more important than mineral sediment input to vertical accretion (Nyman et al., 1990; Nyman and DeLaune, 1991), except during initial phases of delta building (van Heerden and Roberts, 1988). Accretion deficits in Louisiana coastal marshes are caused primarily by inadequate organic matter accumulation (Nyman et al., 1993). Any environmental change that lowers productivity or increases the rate of organic matter removal increases the vertical accretion deficit.

For those areas of active delta building, sediment from the Mississippi River is an essential ingredient in the land-building process. However, upstream reservoirs, changes in agricultural practices and land uses, and bank stabilization measures have reduced average sediment loads in the lower Mississippi River by approximately 67 percent since the 1950s.

1.5.2.1.5 *Relative Subsidence*

Most of the recorded relative sea level change in Louisiana has been related to subsidence. Subsidence is the combined effect of numerous processes, such as compaction of poorly consolidated sediments and faulting. In essence, land areas that experience subsidence “sink,” and their relative elevation above sea level decreases. In areas of the coast where subsidence is high and riverine influence is minor or virtually non-existent, such as in areas of western Barataria Basin and eastern Terrebonne Basin, wetland habitats sink and convert to open water. Estimated subsidence rates for the Deltaic Plain are between 3.0 and 4.3 ft/century (0.19 to 1.3 cm/year) and between 1.3 to 2.0 ft/century (0.4 to 0.6 cm/year) for the Chenier Plain.

1.5.2.1.6 *Relative Sea level Change*

The entire Louisiana coastal zone is experiencing relative sea level change. Sea level change is defined as the net effect of numerous processes that result in the downward displacement of the land surface relative to sea level. For coastal Louisiana, it is controlled by several major factors, such as sea level, compaction of sediment deposits, and geologic faulting. Recent studies have shown that subsurface fluid (e.g., oil and gas) withdrawal may also be a contributor to relative sea level change, but the magnitude of its contribution is not well understood (Morton et al., 2002).

The average rate of sea level change is currently estimated to be between 1.03 and 1.19 cm/year. Until recently, the sea level change rate has been low, accounting for only a small component of the change in relative sea level along the Louisiana coast. However, many experts now predict that the level of the world’s oceans could rise 8 inches over the next 50 years. As the rate of relative sea level change increases, the rate at which coastal wetlands accrete sediment and organic matter, referred to as sediment accretion, must also keep pace or the wetlands will eventually become submerged and be converted to open water. In those situations where coastal wetlands do not accrete enough sediment from riverine sources (e.g., the Mississippi River) and sustain sufficient quantities of organic deposition from vegetation, a "vertical accretion deficit" exists.

1.5.2.1.7 *Hypoxia*

Hypoxia is a significant environmental problem affecting the northern gulf. It is also a problem of National importance that will require action throughout the Mississippi River Basin to solve. Hypoxia exists when dissolved oxygen concentrations are less than those necessary to sustain animal life. Hypoxic zones are sometimes referred to as "dead zones" because marine life cannot survive within them. Mobile organisms leave the hypoxic zone for waters with higher dissolved oxygen concentrations, and those that cannot leave die or are seriously harmed. Fish, shrimp, and zooplankton are less abundant in hypoxic waters (Committee on Environment and Natural Resources (CENR), 2000), as are aerobic benthic organisms in sediments under hypoxic waters.

Hypoxia results when oxygen consumption during decomposition of organic material exceeds oxygen production through photosynthesis and replenishment from the atmosphere (CENR, 2000). Organic matter comes primarily from within the marine ecosystem through algal growth stimulated by nutrients. The Mississippi River and Atchafalaya River transports the nutrient-laden runoff of nearly one half of the continental United States to the gulf.

Hypoxia in the northern gulf is caused primarily by excess nitrogen in combination with stratification of gulf waters (CENR, 2000). For the period 1985 to 1992, the bottom area of the hypoxic zone ranged from 2,730 to 3,510 mi2 (7,070 to 9,090 km2) (**figure 1-8**) (Rabalais et al., 1999). The reduced hypoxic zone during years 1988, 1989, and 2000 are anomalies due to severe drought (i.e. significantly reduced water flows from the Mississippi River and its distributaries into the gulf).

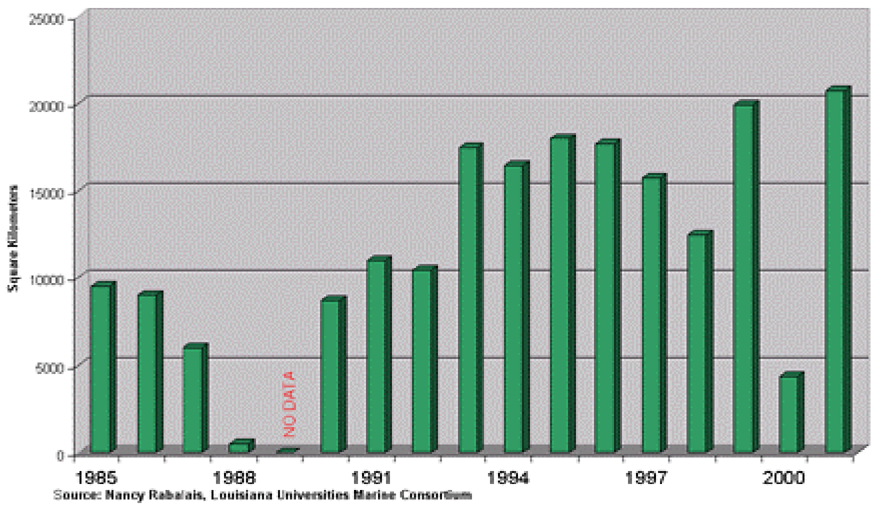

Figure 1-8. Comparative Size of the Hypoxic Area from 1985 to 2001.

In the past, a portion of the Mississippi River's flow would occasionally divert into the coastal wetlands through crevasses or overbank flow. These flows into the wetlands would occur particularly during high river discharges when the maximum levels of sediment and nutrients were also being transported. These diversions would disperse a fraction of the sediments and nutrients into the wetlands, where the marsh vegetation would capture and incorporate them into the cycle of growth, thus reducing the total nutrient load reaching the gulf. Today, more nutrients pass though the study area and into the northern gulf as a result of the loss of wetlands (less wetlands to absorb the nutrients) and the significant reduction in hydrologic connectivity between the river and coastal wetlands (less ability to transport freshwater to wetlands that would absorb the nutrients).

1.5.2.1.8 *Saltwater Intrusion*

Saltwater intrusion occurs when freshwater flows decrease in volume, allowing saltwater from the gulf, which is heavier than freshwater, to move inland or "upstream". Saltwater can then infiltrate fresh groundwater and surface water supplies and damage freshwater ecosystems. The rate of saltwater intrusion depends on the amount of freshwater flows traveling downstream and the water depth in the wetlands, channels, and/or canals. Generally, high-inflow/low-salinity periods occur from late winter to late spring and low-inflow/high-salinity periods from late spring to fall. Saltwater intrusion is the principle factor in the conversion of freshwater habitats to saline habitats. Extreme salinity changes can stress fresh and intermediate marshes to the point where vegetation dies and the wetlands convert into open water (Flynn et al., 1995).

1.5.2.1.9 *Historic Storms And Hurricanes*

Some of the most deadly hurricanes (57) and tropical storms (61) in U.S. recorded history (see **figure 1-9**; note that tropical storms Isidore and Lili are not displayed on this figure) have made landfall on or threatened the Louisiana coast (Roth 1998) due principally to proximity of the Gulf of Mexico, whose tropical waters are ideal for storm formation. Hurricanes and tropical storms have affected coastal Louisiana with impacts ranging from minor inconvenience to major property damage, as well as human and wildlife and fishery losses. These storm events have also had significant morphological impacts along the coast.

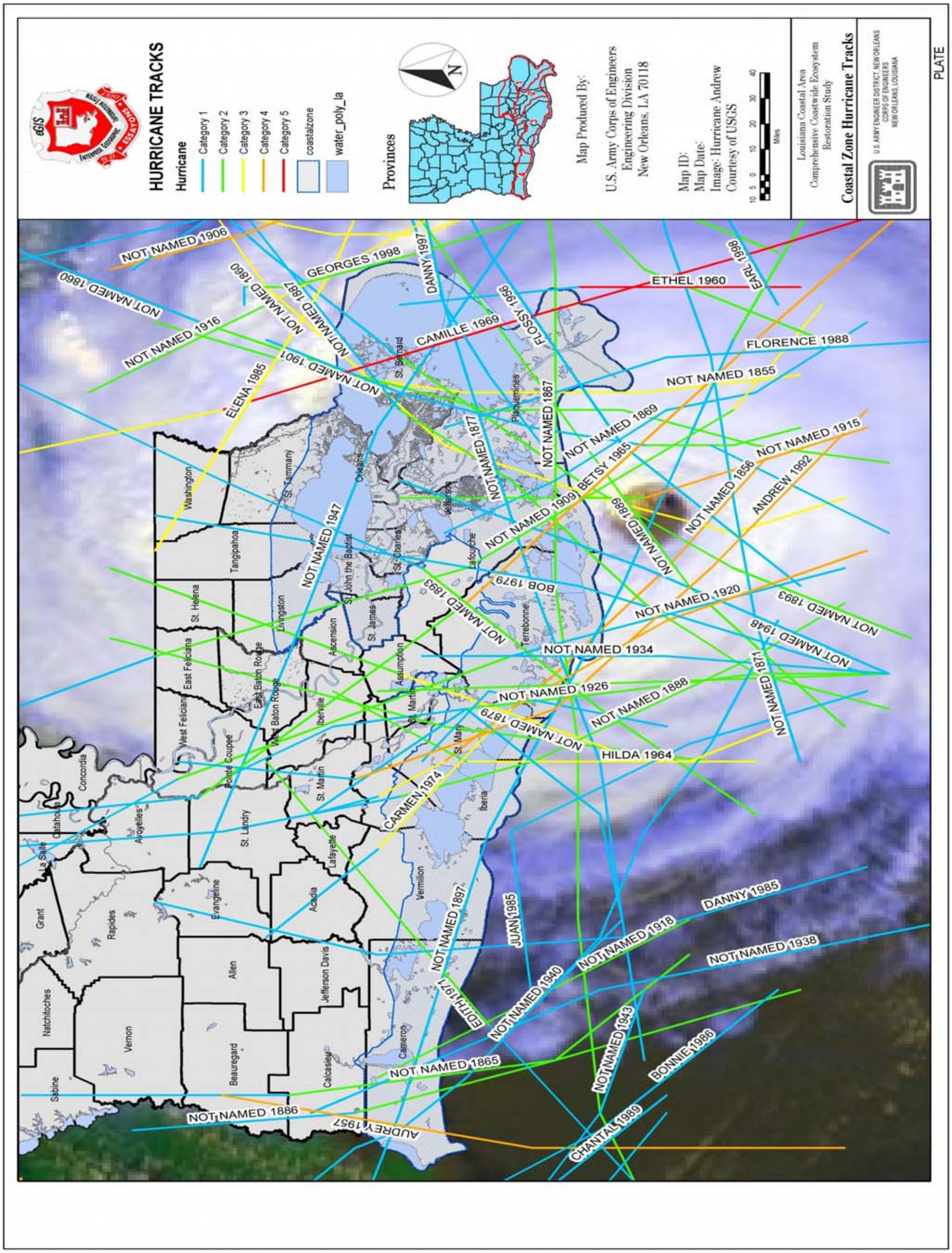

Figure 1-9 Historic hurricane storm tracks impacting Louisiana.

On average, since 1871 a tropical storm or hurricane is expected to affect Louisiana every 1.2 years (Stone et al., 1997; Roth 1998). Hurricanes are ranked (by the Saffir-Simpson Scale) from Category 1 (minimal) through Category 5 (catastrophic), with winds ranging from 75 mph to greater than 155 mph. Tropical depressions/tropical storms typically have winds less than 74 mph and cause minor wind and flood damage to business and residential areas. In contrast, a Category 5 hurricane can cause disastrous flooding and damage across the coast. However, even tropical depressions and storms can have significant impacts in coastal Louisiana due to generally relatively low elevations of the entire area.

The storm surge, a dome of water near the center of the storm, is perhaps the major component of destruction from a hurricane to coastal areas. Additional hazards from hurricanes are high winds, extreme rainfall rates, river flooding, salinity intrusion, sediment transport, tornados, levee collapse, and pollution of surge waters (Huh 2001, Pielke 1997). Louisiana's coastal areas range from approximately 1 to 2 feet above sea level, therefore a storm surge of great height can cause catastrophic damages to life and property. Storm surge flooding across Louisiana is greater than surrounding areas because of its orientation, approximately a 90-degree angle made by the Mississippi Delta in relation to the rest of the gulf coast, which amplifies the effects of the water surge (Roth 1998).

Hurricanes and tropical storms can result in billions of dollars in property damage and many human fatalities (see also section 3.24 Economic Resources). Approximately 3,000 lives have been claimed by hurricanes and tropical storms that made landfall in Louisiana (Roth 1998). Audrey, Louisiana's deadliest hurricane of modern time, was a Category 4 hurricane that killed between 390 and 550 people (**table 1-1**). Audrey destroyed 90 percent of the buildings in the city of Cameron (Sallenger 2000). The agriculture industry, as well as livestock and fisheries farming, can be heavily impacted by a serious storm. Louisiana crops such as sugar cane, cotton, citrus, pecan, and soybeans can be greatly diminished if not completely ruined. Offshore and coastal industries such as oil, public utilities and fisheries can experience loss of boats, ships, tugs, barges, and offshore installations. In addition, fisheries and livestock farming industries can also see a sharp decline in production as catastrophic storms can cause death to marine/freshwater fish and land animals.

Table 1-1
Thirty Deadliest Storms (nationally) that Impacted Louisiana From 1900-1996*

National Ranking	Hurricane	Year	Category	Deaths
6	Audrey (SW La/ N TX)	1957	4	390
8	La (Grand Isle)	1909	4	350
9	La (New Orleans)	1915	4	275
11	Camille (Ms/ La)	1969	5	256
18	Betsy (SE Fl/ SE La)	1965	3	75
20	SE Fl/ La/ Ms	1947	4	51
27	Hilda (La)	1964	3	38
28	SW La	1918	3	34

**Source: Center for Business & Economic Research, University of Louisiana at Monroe*

One major concern for the protection of human life is the limited number of evacuation routes from populated coastal areas. There are approximately 5 interstates and 30 state highways that are located throughout the coastal Louisiana region (**figure 1-10**). If these routes were to become flooded or impassable, then residents of those areas would not be able to escape a storm. In some areas in the coastal region, there is only one route into and out of the city. For example, Highway 1 is the only evacuation route for Grand Isle, Port Fourchon, and for the thousands of people working offshore in the Gulf of Mexico on rigs and platforms (Tyson 2002).

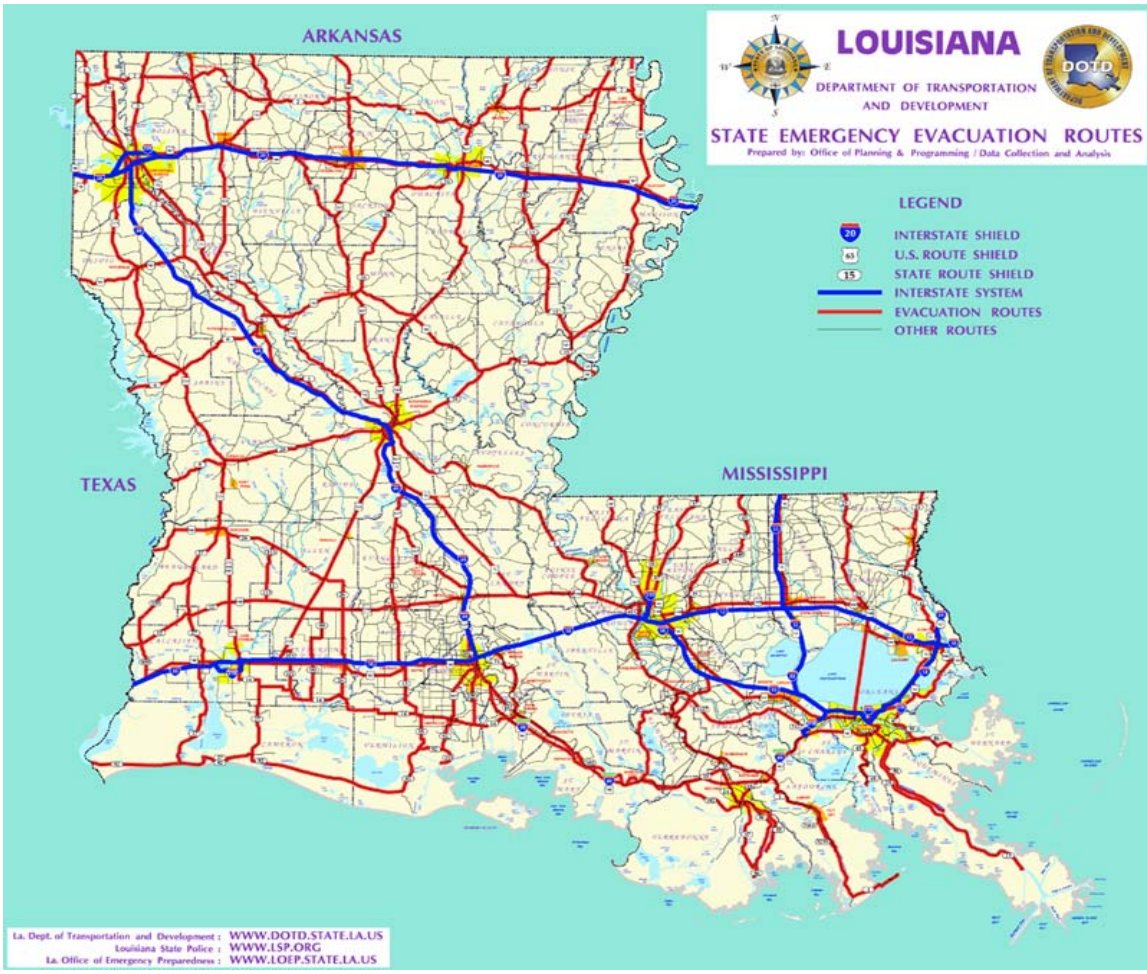

Figure 1-10 Louisiana Emergency Evacuation Route Map. Hurricane evacuation routes in red. *(Source: Louisiana State Department of Transportation and Development)*

The widespread subsidence of coastal wetland areas, in combination with hurricanes and storms, has resulted in potentially deadly circumstances. Dokka (2002) estimated that Highway 1 in Grand Isle sank about 1-2 feet due to subsidence. The loss of elevation in south Louisiana and the growth of open water conditions along the coast make future storms and hurricanes more likely to flood evacuation routes, coastal towns and ports, and stress flood protection levees each year (Challstrom 2002).

1.5.2.1.9.1 *Hurricane Impacts On The Natural Environment*

Hurricanes and storms impact the natural environment resulting in vegetation losses and fish and wildlife losses (see also section 3.6 Vegetation Resources, section 3.7 Wildlife Resources, and section 3.10 Fisheries Resources). The depletion of the barrier shorelines, which buffer storm impacts, is causing adverse effects to the coastal wetlands. Coast 2050 (1998) reports that 30 percent of National tidal wetlands are located on the Louisiana gulf coast. Fresh and intermediate marsh, which includes floating marsh, makes up a substantial part of these wetlands (Chabreck and Linscombe 1978). Lovelace and McPherson (1998) reported that marshes suffered substantial damage caused by wind, tide, and wave action during Hurricane Andrew.

Damages to marsh habitat can be seen as compressed marsh, marsh balls (marsh piled, rolled, or deformed), and sediment deposition in thicknesses that can kill vegetation or sink floating marsh (Dunbar et al., 1992; Jackson et al., 1992). Other wetland damage includes erosion, vegetative scour (plant roots being torn from soil surface), and salt burning (saline water killing or damaging salt-sensitive species) (Dunbar et al., 1992; Jackson et al., 1992; Stone et al., 1993; Stone et al., 1997; Lovelace and McPherson 1998). Storms and hurricanes, depending on strength and intensity, can also blow over, defoliate, and/or cause major structural damage to trees well beyond the coastal zone (Lovelace 1998).

Guntenspergen (1998) reported that coastal wetlands are depleted at a faster rate when a hurricane or storm crosses over Louisiana. Estimates derived for this study indicated that between the years 1956-2000, about 1,900 square miles of coastal wetlands have been lost. Estimates derived by the USGS for the present study indicated that about 23 square miles of wetlands are lost annually (see appendix B Historic and Predicted Coastal Louisiana Land Changes: 1978-2050 of the Main Report).

Wildlife losses from hurricanes and storms reach from the Gulf of Mexico north to beyond the coastal zone of Louisiana. Freshwater fish are a major casualty due, primarily, to movement of water containing low dissolved oxygen concentrations and toxic hydrogen sulfide released from bottom sediments (Tilyou 1993, Lovelace and McPherson 1998). Saltwater fish can also incur great numbers of casualties due to suffocation, clogging of gills with sediment, or gas-bubble disease (Tilyou 1993). Other marine organisms are also affected. Oyster reefs can be smothered by deposition of sediment. After Hurricane Georges, the Chandeleur Barrier Islands lost over a quarter of its sea-grass beds (Turnipseed 1998), which are the basis of the complex food chain. In addition, the Chandeleur Barrier Islands also provides wintering habitat for many birds including piping plover and brown pelican. Marsh losses would also affect wintering birds and ducks. Young wildlife species are especially at risk due to their extreme vulnerability to high winds and storm surges (Lovelace and McPherson 1998).

1.5.2.1.9.2 *Hurricanes And Louisiana Barrier Shorelines/Islands*

The Louisiana barrier shoreline/island system, the first line of defense against hurricanes and storms, provides storm protection to estuaries, wetlands, and coastal populations. These islands take the initial impact of hurricanes and tropical storms. For example, between 1980 and 2002 Shell Island, which protects the Barataria Basin, lost approximately 101.5 feet per year (Connor et al., 2004). Sallenger (2000) reported that Hurricane Andrew stripped sand from 70 percent of the barrier islands, more than 70 km of dune habitat, leaving coastal marshes exposed to future storm events. If coastal land loss is not addressed, the continued erosion of Louisiana's barrier shoreline will result in inland cities becoming the front line for the hurricanes' high wind and storm surge. The depletion of the barrier shoreline is causing the adverse effects from storms and hurricanes to impact coastal wetlands, marshes and cities.

1.5.2.1.9.3 *Hurricane And Tropical Storms Damages*

Since 1965, Louisiana has been hit by 3 hurricanes ranging in intensity from category 3-5, as well as a number of minor hurricanes and tropical storms (**table 1-2**). Even tropical storms can have significant impacts on the study area. Tropical Storm Isidore (September 25-26, 2002), had winds up to 65 miles per hour. Lepore (2002) reported coastal storm surge flooding of 3 to 6 feet above normal tide levels with higher levels in bays. The total cost of damages was $105,000,000. In response to the storm events, which included tropical storm Lili, Louisiana was declared as a state of emergency.

Table 1-2
Thirty Costliest Hurricanes (National Ranking) that Impacted Louisiana from 1900-1996*

National Ranking	Hurricane	Year	Category	Damage
1	Andrew (SE FL/SE LA)	1992	4	$30,475,000,000
4	Betsy (FL/LA)	1965	3	$7,425,340,909
14	Juan (LA)	1985	1	$2,108,801,956
28	SE FL/LA/MS	1947	4	$810,897,436
30	Audrey (LA/ N TX)	1957	4	$802,325,581

**Source: Center for Business & Economic Research, University of Louisiana at Monroe*

1.5.2.1.10 *Climate Changes And Implications For Sea Level Change (Rise)*

Scientists working with the USEPA expect that increasing concentrations of greenhouse gases are likely to accelerate the global rate of climate change, although it is much less clear whether regional climate will become more variable. See: (http://yosemite.epa.gov/oar/globalwarming.nsf/content/climate.html).

Estimates that the average global surface temperature could rise 1-4.5^{o}F (0.6-2.55^{o}C) in the next 50 years have several implications. Scientists currently are unable to determine which parts of the U.S. will become wetter or drier, but there is likely an overall trend toward increased precipitation and evaporation, more intense rainstorms and drier soils. See: (http://yosemite.epa.gov/OAR/globalwarming.nsf/content/ClimateFutureClimate.html).

Considering factors such as warmer temperatures, melting glaciers, increased precipitation and snowfall, the Third Assessment Report of Working Group I of the Intergovernmental Panel on Climate Change estimate that sea level changes will rise 9 to 88 cm (3.5 to 34.3 inches) by year 2100. See: (http://yosemite.epa.gov/OAR/globalwarming.nsf/UniqueKeyLookup/SHSU5BWJE7/$File/wg1_science-sum.pdf).

1.5.2.2 Human Activities Influencing Coastal Land Loss

1.5.2.2.1 *General*

In many areas of the United States, wetland losses occur primarily because of direct causes: people drain or fill wetlands to improve their suitability for development, and those filling or draining the wetlands are clearly responsible for the wetland loss. While some direct losses occur in Louisiana, the majority of losses in the state are caused indirectly. Indirect losses occur when human activities alter the process of land building and maintenance. To understand these indirect effects, it is important to understand the processes that built the landscape and which, under natural circumstances, maintain it.

Many human activities at the coast have interrupted or altered the natural processes. Some of these activities are widespread across the coast and can affect large areas. These include: construction and management of levees and flood control structures on the Mississippi River that alter sediment supply to wetlands and limit the building of new lands; construction of canals and associated side-cast material that disrupt the internal hydrology of the estuaries and wetlands; and increased boat traffic and construction of jetties and other structures to facilitate navigation. Other activities likely have localized effects, including the extraction of oil, gas, and groundwater and the introduction of nutria that graze extensively on wetland plants.

1.5.2.2.2 *Flood Control*

Following European settlement in coastal Louisiana, humans began to modify the Mississippi River. Levees were built and maintained to limit flooding of populated areas and agricultural areas, and to support interests such as navigation. Levees serve two general purposes: 1) contain river flows and 2) protect against storm surges. There are approximately 2,250 miles of levees that have been constructed in coastal Louisiana to contain the Mississippi River and its distributaries and to protect agricultural and urban areas from flooding. Several hurricane protection levee projects are in various stages of design and construction, including Morganza to the Gulf and Donaldsonville to the Gulf projects. These projects would add hundreds of miles of new levees in the coastal zone.

An unintended consequence of the construction of the levee system has been to accelerate coastal land loss and reduce the sustainability of the coastal ecosystem by reducing riverine influences to many of the coastal wetlands. In some instances, wetlands habitats have become isolated from the freshwater, sediments, and nutrients of the Mississippi River and its distributaries. With a reduced or absent hydrologic connection to the river, marine influences in the areas can predominate. In the short-term, this influence can result in greater habitat and wildlife diversity, as well as some land loss. In the long-term, coastal habitats can disappear without a renewed or enhanced connection to freshwater, sediment, and nutrients.

1.5.2.2.3 *Navigation*

There are 10 major navigation channels, both deep draft and shallow draft, within the LCA. While these channels support the local, regional, and National economies, they also serve as conduits for saltwater intrusion in some areas and barriers to the distribution of freshwater, sediment, and nutrients to wetland habitats in other areas. The navigation channels, such as the GIWW, also subject inland areas to more dramatic tidal forces and wave action, thereby increasing erosion.

1.5.2.2.4 *Construction Of Canals And Dredged Material Banks That Disrupt The Internal Hydrology Of The Delta*

There have been large-scale changes in the hydrology of the coast due to the construction of canals, their associated side-cast material and the incidental impoundment, or hydrologic isolation, of extensive areas. By the end of the 20th century, over 9,300 miles of canals had been dredged in support of navigation, drainage, and oil-and-gas development. Canals alter natural hydrology in two main ways. First, canals that stretch from the Gulf of Mexico inland to freshwater areas allow saltwater to penetrate much further inland, particularly during droughts and storms, which has had severe effects on freshwater wetlands (e.g., Wang, 1987). Second, dredged material banks, which are much higher than the natural marsh surface, alter the flow of water across wetlands. This changes important biogeochemical and ecological processes, including chemical transformations, sediment transport, vegetation health, and migration of organisms. Because of the presence of dredged material banks, partially impounded areas have fewer, but longer periods of flooding and reduced water exchange when compared to unimpounded marshes (Swenson and Turner, 1987; Boumans and Day 1994). This results in increased waterlogging and frequently plant death. Importantly, dredged material banks also block the movement of sediments resuspended in storms, which play a significant role in sustaining land elevations (Reed 1997). By altering salinity gradients and patterns of water and sediment flow through marshes, canal dredging, which mostly occurred between 1950 and 1980, not only directly changed land to open water, but also indirectly changed the processes essential to a healthy coastal ecosystem.

1.5.2.2.5 *Increased Vessel Traffic And The Construction Of Jetties*

Wave erosion along exposed shorelines is a substantial factor contributing to coastal land loss, and in many areas this is an entirely natural process. Human activities that increase wave actions in coastal areas contribute to accelerated losses by erosion. These activities include construction of canals and navigation channels that widen rapidly due to the operation of vessels that generate wakes (Johnson and Gosselink, 1982). At the barrier shoreline, jetties have been built around many tidal inlets to facilitate navigation from the gulf into rivers and navigation channels. These alter the longshore drift of sediment along the shore that maintains barrier shorelines, and in many areas rapid erosion of beaches and shorelines has occurred on the ‘down drift’ side of the jetties (Penland et al., 1992).

1.5.2.2.6 *Oil and Gas Infrastructure*

With the discovery of oil and gas deposits in coastal Louisiana during the early 1920s, a vast network of canals, pipelines, and production facilities have been created to service the industry. Today, an estimated 9,500 miles of oil and gas pipelines crisscross the coastal wetlands of Louisiana. In addition, there are approximately 50,000 oil and gas production facilities located in the LCA. Canals that stretch from the Gulf of Mexico inland to freshwater areas allow saltwater to penetrate much farther inland, particularly during droughts and storms, which has had severe effects on freshwater wetlands (Wang, 1987).

Dredged material banks, which are much higher than the natural marsh surface, and the many smaller canals dredged for oil and gas exploration, alter the flow of water across wetlands. This hydrological alteration changes important hydrogeomorphic, biogeochemical, and ecological processes, including chemical transformations, sediment transport, vegetation health, and migration of organisms. Because of the presence of dredged material banks, partially impounded areas have fewer but longer periods of flooding and reduced water exchange when compared to unimpounded marshes (Swenson and Turner, 1987). This results in increased waterlogging and frequently in plant death. Importantly, dredged material banks also block the movement of sediments resuspended in storms, which play a significant role in sustaining land elevations (Reed, 1997). By altering salinity gradients and patterns of water and sediment flow through marshes, canal dredging, which mostly occurred between 1950 and 1980, not only directly changed land to open water, but also indirectly changed the processes essential to a healthy coastal ecosystem.

1.5.2.3 Contributions To Land Loss

Direct losses (caused by an action and occur at the same time and place) can be quantified and attributed to specific causes with reasonable accuracy. Since the 1970s, direct losses have been dealt with through a permitting program required by Section 404 of the Clean Water Act as well as state laws. It is more difficult to assign specific causes to indirect land losses (caused by an action and are later in time or farther removed in distance). This is due to the natural variability of coastal processes and the complex way that human activities have altered these processes. Loss of coastal wetlands is most commonly caused by a number of factors, natural and human-induced, interacting to produce conditions at the local scale where wetland vegetation can no longer survive. For barrier shorelines, similarly complex interactions among storm events, longshore sediment supply, coastal structures and inlet dynamics, contribute to the erosion and migration of beaches, islands and cheniers.

Extensive coastal land loss in the mid-late 20th century occurred partially because human activities changed the processes essential to maintain the coastal ecosystem and limited the processes required to rebuild it. The magnitude and variety of these changes, and their interaction with natural landscape processes, means looking at any one of these factors in isolation would prevent a full understanding of the change in balance between land gain and land loss. While many studies have examined the individual factors contributing to land loss, few have attempted to isolate their individual contributions.

Various studies have attributed land loss to different causes. Turner (1997 and 2001) claimed that the majority of the loss was due to canals and their direct and secondary impacts. Gagliano (1998) indicated that loss was mainly due to deep faulting caused by oil and gas extraction and would continue in the foreseeable future. Morton et al., (2002) claimed that some of the cause was faulting, but now that oil and gas extraction had slowed, faulting would slow. Penland et al., (2000) made a detailed classification of the land loss that occurred between 1932 and 1990 within the Mississippi River Deltaic Plain. The loss was classified by 1) geomorphic form and 2) primary processes responsible for the loss. Geomorphic form is the physical place where loss occurs.

1.5.2.4 Geomorphic Form Classification Results

The results of the coastal land loss geomorphic classification (Penland et al., 2000) show that of the 690,932 acres of land loss between 1932 and 1990, approximately 70 percent of loss was attributed to interior loss and 30 percent was attributed to shoreline loss. For the interior loss class, interior ponding accounted for approximately 57 percent followed by interior channels at 13 percent. For shoreline loss, the lake class at 9 percent, the gulf class at 5 percent, and the channel class at 5 percent followed the bay class at 11 percent.

Penland et al., (2000) also identified three basic processes responsible for coastal land loss:

1. submergence (relative water level on the marsh increasing due to both human and natural causes);
2. erosion (loss due to wind and waves); and
3. direct removal (dredging of marsh for various reasons).

Altered hydrology resulting from the loss of riverine sediments, freshwater and nutrients, saltwater intrusion, interruption of sheet flow, and other causes accounted for a majority of land loss attributed to submergence. Natural waves and increased tidal forces accounted for a majority of the land loss attributed to erosion. Direct removal of land through the construction of various types of channels (e.g., for navigation and oil and gas extraction) contributed to coastal land loss.

1.5.2.5 Land Loss Measurement

1.5.2.5.1 *Overview*

A recent USGS study estimates that a total land loss of 674 square miles and a total land gain of 161 square miles will occur by 2050 (Barras 2003). Sources of land gains considered in the estimate include the following: Coastal Wetlands Planning, Protection and Restoration Act (Public Law 101-646, title III) projects: 54 square miles; Caernarvon Freshwater Diversion: 25 square miles; Davis Pond Freshwater Diversion: 53 square miles; Atchafalaya Delta building: 14 square miles; and Mississippi River Delta building: 15 square miles. Note that these projected land gains for the Davis Pond and Caernarvon Freshwater Diversions include expected new land and reductions in land lost without the projects. Thus, the estimated projected net land loss was 513 square miles (see also appendix B Historic and Predicted Coastal Louisiana Land Changes: 1978-2050).

Summarized historic and projected land loss rates presented in this report for the LCA are:

- 1956-1978 = 39.4 mi^2/year
- 1978-1990 = 34.9 mi^2/year
- 1990-2000 = 23.9 mi^2/year
- 2000-2050 = 10.3 to 13.5 mi^2/year

There are several explanations for the reduced land loss rate projected between 2000 and 2050 and the rate of loss between 1990 and 2000. Actively managed areas in the coastal area were excluded in the future projection of land loss. These lands were included in the 1990-2000 rate of land loss calculation and accounted for 3 mi^2/year of the 23.9 mi^2/year total for that time period. Also, total land in the coastal area has been reduced by 10 percent from 1978-2000; therefore, less land can be lost in the projections from 2000-2050. Further information regarding this subject can be found in the following pages and appendix B "Historic and Predicted Coastal Louisiana Land Changes: 1978-2050" of the Main Report.

1.5.2.5.2 *Comparisons With Previous Projections*

The projection of land-water conditions is presented in **table 1-3** using the same fundamental methodology as the projection included in the Coast 2050 Plan (LCWCRTF 1998). However, the projected magnitude of change by 2050 is the net loss of 513 square miles (sq m) (1,329 sq. km), rather than the almost 1,000 sq m (2,590 sq. km) that had been projected in 1998.

There are several reasons for this change in projection:

- The 1998 projection was based on land loss rates between 1974 and 1990. The base period for the current projection is 1978 to 2000, and thus the lower rates in the 1990s project lower rates into the future.

- The spatial patterns of land loss between 1974 and 1990 projected in the earlier analysis were based on data derived from aerial imagery, and the procedure used to develop the maps focused on land loss rather than land gain (Britsch and Dunbar 1993). Thus, the 1974 to 1990 data encompassed only "gross loss" and did not include any land gain occurring in the study area. The current analysis includes both loss and gain, and the net result of both processes is projected forward in a spatially explicit manner.

Table 1-3
Net Land Loss Trends by Province from 1978 to 2000

	1978-1990 Net loss (Mi^2)*	1990 - 2000 Net Loss (Mi^2)	1978 - 2000 Land Loss (Mi^2)	Net Loss 22 Years (Mi^2/Year)	% Total Loss by Area
Subprovince 1	52	48	100	4.5	15%
Subprovince 2	148	65	213	9.7	32%
Subprovince 3	134	72	206	9.4	31%
Subprovince 4	85	54	139	6.3	21%
Total	419	239	658	29.9	100%

**1978-1990 Net loss figures were based on Barras et al. 1994. The 1978 to 1990 basin level and coastwide trends used in this study were aggregated to reflect LCA subprovinces for comparison with the 1990-2000 data. The basin boundaries used in Barras et al. (1994) were based on older CWPPRA planning boundaries and are not directly comparable to the LCA boundary used to summarize the 1990 to 2000 trend data. The 1990 to 2000 net loss figures include actively managed lands for comparison purposes with the 1978 to 1990 data.*

- The Britsch and Dunbar (1993) data set was based on analysis of aerial photography and was largely restricted to the nonforested areas of the coast. Little data were available for the upper basins, dominated by cypress-tupelo swamps and bottomland hardwoods. In the 1998 analysis, expert judgment was used to estimate the future loss in these areas and resulted in an estimate of over 360 sq m (932 sq. km) of swamp loss (out of the 1,000 sq m [2,529 sq. km]). This is now assumed to be an overestimate. In the current analysis, the Landsat TM (satellite databases) used for 1990 and 2000 covered the entire area. Therefore, using the same methodology, quantitative projections for the entire LCA study area were possible.

- The loss shown in actively managed areas in the Britsch and Dunbar (1993) data was projected in the 1998 analysis. The current projection, however, excluded these areas because the LCA Land Change Study Group recognized that, at the time of the imagery, their classification as either land or water reflected the prevailing management regime rather than any trajectory of change in the coastal landscape.

The LCA Land Change Study Group, a part of the Project Delivery Team (PDT), considers that the net contribution of these four factors, and other minor differences in the projection methodology, account for the differences in the magnitude of the future loss projection. Most of these changes in the projection procedure represent a more thorough consideration of the factors contributing to coastal land change as a result of our increasing understanding of the coast and the use of improved technology. For more information on land loss see appendix B "Historic and Predicted Coastal Louisiana Land Changes: 1978-2050" of the Main Report.

1.5.2.5.3 *Patterns Of Land Loss And Gain 1978-2000*

Across much of the Louisiana coast, wetland loss and shoreline erosion continue largely unabated. The rates of Louisiana's coastal land loss have varied over time (**figure 1-11**). For example, the conversion of numerous large areas [greater than 40 acres (1,000 hectares)] of interior marsh to open water, prevalent in the 1956 to 1978 period, continued to occur, to a lesser extent, in the 1978 to 1990 period and further decreased in the 1990 to 2000 period (**table 1-3**).

Continued shoreline erosion and smaller interior marsh ponding are the primary loss patterns dominating the last decade. Interior ponds range in size from 2.5 to 5.0 acres (1 or 2 hectares) to 125 acres (50 ha), with the majority of ponds occurring within the coastal fresh to intermediate marshes. Detectable shoreline erosion in larger lakes, bays, and ponds ranged from 165 to 1,000 feet (50 to 300 m).

1.5.2.6 Projected 2000-2050 Land Change Summary

According to the latest USGS information (see appendix B Historic and Predicted Coastal Louisiana Land Changes: 1978-2050), the projected 2000-2050 land changes, based on the analysis described previously, are a future land loss of 674 sq m (1,746 sq km) and a future land gain of 161 sq m (417 sq km). These gains were from the following sources: CWPPRA projects, 54 sq m (140 sq km); Caernarvon diversion, 25 sq m (65 sq km); Davis Pond diversion, 53 sq m (137 sq km); Atchafalaya Delta building, 14 sq m (36 sq km); and Mississippi River Delta building, 15 sq m (39 sq km). Land gains for Davis Pond and Caernarvon diversion reflect new land created and land projected to be saved from loss by the projects' operations over the next 50 years. Thus, the projected net land loss is 513 sq m (1,329 sq km) (**table 1-4**). Land loss curves depicting land loss from 1956-2050 project gross loss (without projected gain) at 2,199 sq m (5,695 sq km) and net loss (with projected gains) at 2,038 sq m (5,278 sq km) over this 94-year period. Patterns of past and predicted land loss and gain are illustrated in **figure 1-11**.

Table 1-4
Projected Net Land Loss Trends by Subprovince from 2000 to 2050.
The projected total land gain is 161 square miles.
The projected total loss is 674 square miles.

	Land in 2000 sq mi	Projected Land in 2050 sq mi	Net Land Loss sq mi	% Land loss between 2050 and 2000	Land Loss sq mi/yr	% Total loss by area
Subprovince 1	1,331	1,270	61	4.61%	1.23	12%
Subprovince 2	1,114	928	186	16.68%	3.71	36%
Subprovince 3	1,975	1,746	229	11.59%	4.58	45%
Subprovince 4	1,431	1,394	37	2.59%	0.74	7%
Total sq mi sq km	5,851 15,154	5,338 13,825	513 1,329	8.77%	10.26 26.57	100%

Note that total percentage of land loss is the percentage of total net land loss (513 square miles) in 2050 to the existing land (5,851 square miles) in 2000.

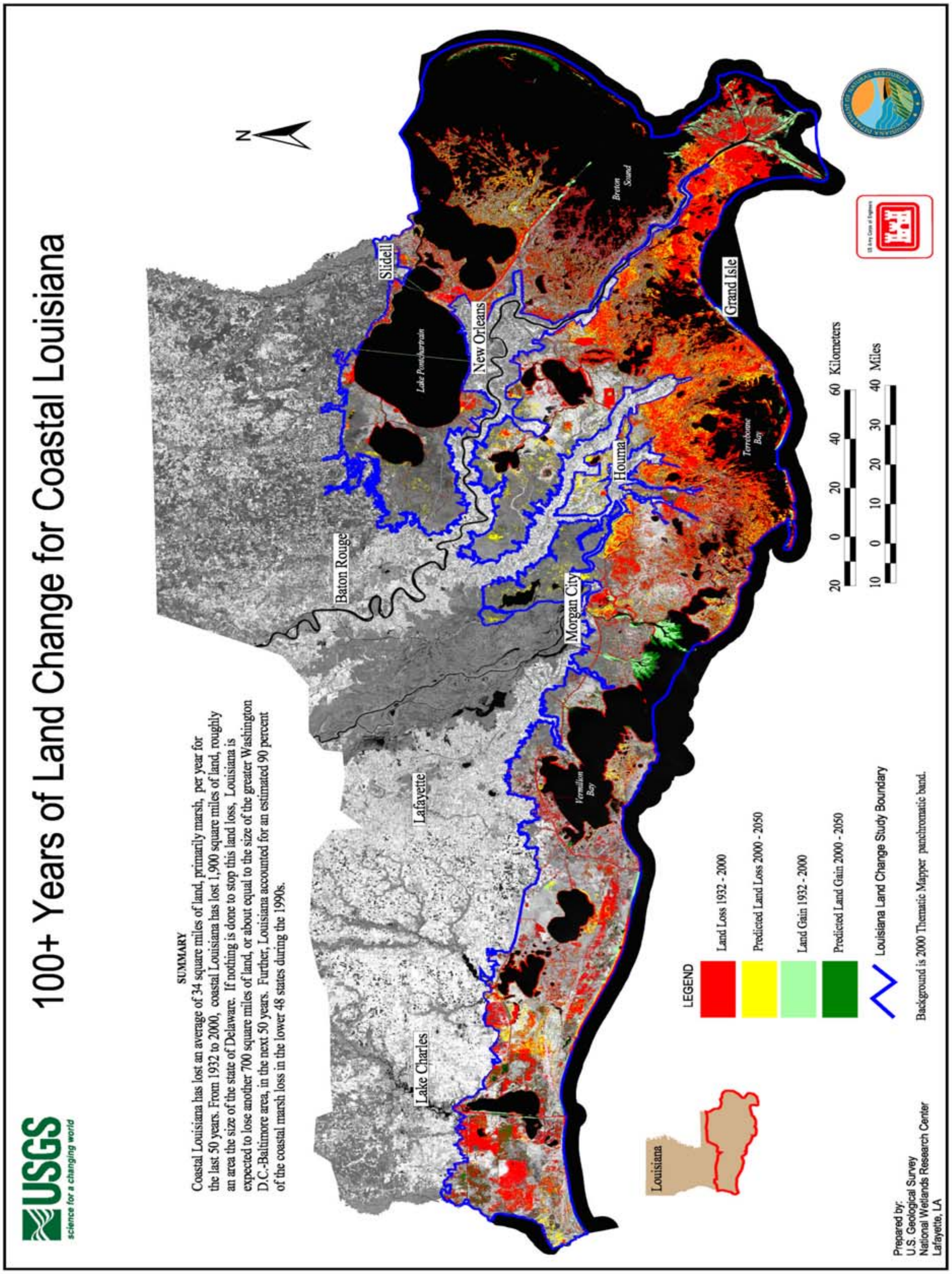

Figure 1-11. Past and projected land changes from 1932-2050.

1.5.2.7 Coastal Land Loss In The Future

The mid to late 20th century was clearly a period of massive human influence on the Louisiana coastal ecosystem and the resulting ecosystem degradation has been described above. However, the question must be asked as to whether these process changes will continue into the future. Much of the alteration of the coastal landscape associated with dredging of canals for oil and gas exploration and for navigation occurred between 1950 and 1980. Thus the direct effects of these extensive dredging activities are not expected to occur again. However, the indirect and ongoing effects of these activities on land loss, such as in alterations to marsh hydrology or basin-scale salinity gradients, are expected to continue in the future.

More chronic regional-scale problems such as subsidence and altered patterns of sediment delivery from the Mississippi River will also likely have the same effects in the future as in the past. Although recent data (Morton et al., 2002) suggest that extensive hydrocarbon extraction from subsurface reservoirs may have led to localized high rates of subsidence in previous decades, the greatest volumes of hydrocarbons were extracted in the 1960s and 1970s, at least in the fields examined by Morton et al. The extraction likely reactivated faults leading to the subsidence, but the timing of fault movement relative to mineral extraction has yet to be clearly identified. Thus, it is possible that localized high subsidence rates identified in recent decades may not continue in the future.

The effects of future changes in climate and climate variability are difficult to predict. Some of these effects, such as changes in rates of sea-level rise are potentially important for future land loss. Louisiana coastal wetlands have been subjected to high rates of relative sea-level rise for centuries at least due to high subsidence rates associated with the compaction and dewatering of deltaic sediments. Some Louisiana marshes have adjusted to these high rates, and still survive in areas where measured rates from tide gauges are over 1 cm per year (cm/yr), and others are experiencing stress which may in part be driven by the relative sea-level rise. Morris et al., (2002) recently predicted that salt marshes in areas of high sediment loading, such as those in Louisiana, the limiting rate of relative sea-level rise is at most 1.2 cm/yr. Future increases in eustatic sea level are projected to be approximately 20 cm by the year 2050 (Scavia et al., 2002) although there is much uncertainty associated with these predictions.

While this suggests that many Louisiana marshes may currently be at their limit with regard to relative sea-level rise and may deteriorate markedly under future sea level rise conditions, Morris et al., (2002) considered tidal flooding to be the primary determinant of sediment deposition. In Louisiana coastal marshes, it is well documented that high water events associated with frontal passages and tropical storms and hurricanes deliver most of the sediment that is currently deposited in coastal marshes (Reed 1989; Cahoon et al., 1995). These factors undoubtedly contribute to sustainability of existing Louisiana marshes and it is not known how marshes will accommodate future increases in relative sea level. If some Louisiana marshes can survive high subsidence-induced rises in water level, these studies suggest that future sea level rise may not increase rates of land loss.

Clearly future land loss and degradation of the ecosystem depends on the interaction among many factors – some of which are unpredictable and many of which are expected to change in the future. The understanding of coastal land loss processes presented here, provides a sound foundation for minimizing future loss and reviving the ecosystem through restoration of those processes that naturally built and maintained the coast.

1.6 NEED FOR ACTION

The cumulative effect of human activities, both past and present, has been to tilt the balance between land building and land loss in the direction of net land loss. The reintroduction of riverine processes and resources, as well as the management of activities within the coastal zone consistent with the objectives of wetland restoration, is needed in order to achieve a balanced and sustainable system. Consistency in operation and management of all existing and future measures and activities to optimize multiple system outputs would be required to ensure the success of any restoration program.

Needs in the study area include:

Prevent future land loss where predicted to occur

Addressing this need would create and sustain diverse coastal habitats, sustain wildlife and plant diversity, and sustain socio-economic resources. Effective measures to reverse coastal land loss should affect plant communities, in their root zone, in such a way as to promote healthy growth and reproduction, plant succession, or revegetation of denuded surfaces. Increasing nutrients and sediments in the estuarine area would increase the growth of marsh vegetation and slow the rate of land loss. Increased plant growth would result in greater production of organic detritus that is essential for a high rate of fisheries and wildlife production. Production of phytoplankton and zooplankton would increase in areas where turbidity is not limiting, and, as a result, the harvest of sport and commercial finfish and shellfish that depend on these microorganisms would increase.

Restore fundamentally impaired or mimic deltaic processes through river reintroductions

Addressing this need would reduce habitat deterioration by increasing nutrients and sediments delivered to the estuarine-marsh areas, which would in turn increase marsh vegetation sustainability and improve fish and wildlife production. In addition, restoring riverine influences to coastal wetlands and creating wetlands would help address the need to reduce the nutrient loading into the northern gulf and to reduce the hypoxic zone. This need can be met by restoring or mimicking distributary flows, crevasses, and over-bank flow, as well as mechanical marsh creation with river sediment, if sustained by freshwater diversions.

Restore or preserve endangered critical geomorphic structures

Addressing this need would restore geomorphic structures, such as gulf shoreline barrier islands, barrier headlands, and chenier ridges. These features are essential to maintaining the integrity of coastal ecosystems because they are an integral part of the overall system and represent the first line of defense against marine influences and tropical storm events.

Protect vital local, regional, and national socio-economic resources

Addressing this need would reduce the increased risk of damage to cultures, communities, infrastructure, business and industry, and flood protection. Accelerated land loss and ecosystem degradation places over $100 billion of infrastructure at increased risk to damage as a result of storm events. This need could be met by increasing the marsh's capacity to buffer hurricane-induced flooding through wetland creation and sustenance and retention of barrier island systems.

1.7 OPPORTUNITES

1.7.1 Saving Louisiana's Coastal Wetlands– Initial Phase

Over the past three decades, both the Federal government and the State of Louisiana have established policies and programs that are intended to halt and reverse the loss of Louisiana's coastal wetlands and to restore and enhance their functionality.

1.7.1.1 Multi-Use Management Plan for South Central Louisiana

Awareness of Louisiana's coastal land loss problem resulted in part from the publication of the 1972 report *"Environmental Atlas and Multi-Use Management Plan for South-Central Louisiana"* (Gagliano et al., 1972). This report provided an initial assessment of the extent and magnitude of the land loss problem. Coastal resource management in Louisiana also accelerated once Louisiana adopted and began participating in the Federal Coastal Zone Management program in 1978. Shortly thereafter, the state developed its first coastal zone management plan. One of the primary objectives of this plan was to ensure that future development activities within the coastal area are accomplished with the greatest benefit and the least amount of environmental damage.

1.7.1.2 Act 6, LA. R.S. 49:213 *et seq.*

In 1989, the constitution of the State of Louisiana was amended with enactment and voter approval of Act 6, LA. R.S. 49:213 *et seq*. Also known as the Louisiana Coastal Wetlands Conservation, Restoration and Management Act, Act 6 established the Wetlands Conservation and Restoration Authority, the Louisiana Governor's Office of Coastal Activities, and the Coastal Restoration Division (CRD) within LDNR. With the creation of the CRD, Act 6 empowered the LDNR as the lead state agency for the development, implementation, operation, maintenance, and monitoring of coastal restoration projects. Chief among its many functions, the CRD has the lead for the development and implementation of state-sponsored coastal restoration projects. In addition, the CRD acts as the state's designated liaison for the Coastal Impact Assistance Fund (CIAP), which was authorized by Congress in 2001 to provide a one-time appropriation of $150 million to assist states in mitigating impacts from Outer Continental Shelf oil and gas production. In 2001, Louisiana received a one-time allocation from the CIAP of $26.4 million, which was used to fund various state and local coastal activities and projects including: monitoring, assessment, research, and planning; habitat, water quality, and wetland restoration; coastline erosion control; and control of invasive non-native plant and animal species.

Act 6 also created the Wetlands Conservation and Restoration Fund (WCRF), which dedicates a portion of the state's revenues from severance taxes on mineral production (*e.g.*, oil and gas) to finance coastal restoration activities and projects. Currently, the WCRF provides approximately $25 million per year to support coastal restoration activities and projects. Finally, Act 6 requires the State to prepare and annually update a *Coastal Wetlands Conservation and Restoration Plan.* This plan provides location-specific authorizations for the funding of coastal restoration projects from the WCRF.

1.7.1.3 Barataria-Terrebonne National Estuary Program

Another important Federal initiative in coastal Louisiana is the Barataria-Terrebonne National Estuary Program (BTNEP). Established in 1990 as part of the U.S. Environmental Protection Agency's (USEPA) National Estuary Program, the BTNEP is a partnership for the study of natural and man-made causes of environmental degradation in the Barataria-Terrebonne watershed and for protection of the watershed from further degradation.

1.7.1.4 Coastal Wetlands Planning, Protection, and Restoration Act

While the Federal government has been concerned with and involved in Louisiana's coastal land loss problem for decades, enactment of the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) in 1990 marked the first Federal statutory mandate for restoration of Louisiana's coastal wetlands. The CWPPRA Task Force, composed of five Federal agencies (NMFS, NRCS, USACE, USEPA, and USFWS) and the State of Louisiana, prepared a comprehensive restoration plan that would coordinate and integrate coastal wetlands restoration projects to ensure the long-term conservation of coastal wetlands of Louisiana. The plan was adopted in 1993. The Task Force also prepared and adopted an annual Project Priority List. As of January 2004, 12 priority lists have been approved; there are 127 active projects approved for implementation and 64 completed projects. These projects include gulf and inland shoreline protection, sediment and freshwater diversions, terracing, vegetative plantings, marsh creation, and barrier island restoration. CWPPRA provides $5 million annually for coastal restoration planning and roughly $50 million each year for the construction of coastal protection and restoration projects.

1.7.1.5 Coast 2050

While the coastal restoration programs and projects described above reduced coastal land loss and enhanced the health and functionality of portions of Louisiana's coastal ecosystem, Federal and state agencies, leading scientists, and other stakeholders realized that these efforts were not sufficient to address the magnitude of the land loss problem and to ensure a sustainable coastal ecosystem. In 1998, Federal and state agencies, local governments, academia, and numerous non-governmental groups and private citizens reached consensus on a conceptual plan for restoration of the Louisiana coast. Entitled *Coast 2050 – Toward a Sustainable Coastal Louisiana,* the plan presented a conceptual framework for achieving sustainability throughout coastal Louisiana. The plan integrates coastal management and coastal restoration approaches, and adopts a multiple-use approach to restoration planning. Among other contributions, the Coast 2050 Plan provides new quantitative techniques for projecting land loss patterns into the future, a coastwide assessment of subsidence rates and patterns, and a comprehensive consideration of changes in fish and wildlife populations. The Coast 2050 plan establishes regional and coastwide common strategies and programmatic recommendations.

The Coast 2050 Plan was a direct outgrowth of lessons learned from implementation of restoration projects through CWPPRA and reflected a growing recognition that a more comprehensive "systemic" approach was needed. The Coast 2050 Plan was the basis for the May 1999 report, entitled Section 905(b) (WRDA1986) Analysis Louisiana Coastal Area, Louisiana --Ecosystem Restoration. This reconnaissance level effort evaluated the Coast 2050 Plan as a whole and expressed a Federal interest in proceeding to the feasibility phase. This report was the precursor to the LCA Ecosystem Restoration Study.

1.7.1.6 Governor's Committee On The Future Of Coastal Louisiana

In February 2002, the Governor's Committee on the Future of Coastal Louisiana (COFCL) prepared a report, "Saving Coastal Louisiana: Recommendations for Implementing an Expanded Coastal Restoration Program," which provided recommendations as a starting point for a renewed and expanded coastal restoration effort. The COFCL report characterizes Louisiana's land loss crisis as an emergency of untold cost to the state of Louisiana and the nation that must be confronted now, with all available resources. The devastation of the coastal land loss will, according to the COFCL report, directly affect our nation's security, navigation, energy consumption, and food supply. The COFCL report further elaborates that the potential loss of lives, infrastructure, industry, ecosystems and culture cannot be overstated.

1.7.1.7 Water Resources Development Act Restoration Actions

The Water Resources Development Acts (WRDA), authorize the Secretary of the Army and the USACE to study and/or implement various projects and programs for improvements to rivers and harbors of the United States and for other purposes. While not specifically environmental laws, a number of Water Resources Development Acts contain general environmental provisions pertinent to the Civil Works water resources development program or to the management of environmental resources. A number of sections from these Acts pertain to specific projects or studies for environmental purposes. The WRDA 1986 made numerous changes in the way potential new water resources projects are studied, evaluated, and funded. The major change is that the law now specifies greater non-Federal cost sharing for most USACE water resources projects. Caernarvon and Davis Pond are the two large scale freshwater diversion projects which divert Mississippi River water to counteract saltwater intrusion, to help offset marsh subsidence, and to enhance fish and wildlife. These projects are designed to benefit over 40,000 acres of wetland habitat.

Section 1135 (PL 99-662) of WRDA 1986 authorizes the USACE to review the operation of its existing water resources projects to determine the need for modifications in structures and operations for the purpose of improving the quality of the environment in the public interest. A maximum $25 million annual limit was authorized for this section with 25 percent of the cost of any modification to be paid by a non-Federal sponsor.

Section 204 (PL 102-580) of the WRDA 1992 authorized the Secretary of the Army to carry out projects for the protection, restoration, and creation, of aquatic and ecologically related habitats, including wetlands, in connection with dredging for construction, operation, or maintenance of an authorized Federal navigation project.

1.7.1.8 Louisiana State Restoration Projects

The state of Louisiana partners with private companies and agencies within the state, and the Federal government, to create, restore, and protect wetlands and shoreline from degradation. The types of projects include hydrologic restoration, beneficial use of dredged material, marsh management, marsh creation, shoreline protection, freshwater diversion, vegetation planting, sediment and nutrient trapping, sediment diversion, and barrier island restoration. These projects are scattered within the four subprovinces of the coastal zone of Louisiana. As of 2003, the total acreage created, restored, or protected for Subprovince 1 is 2,443 acres, Subprovince 2 is 9,143 acres, Subprovince 3 is 4,865 acres, and Subprovince 4 is 4,574 acres.

1.7.1.9 Vegetation Restoration Projects

The LDNR, NRCS, and Soil and Water Conservation Committee (SWCC) are the agencies involved with vegetative plantings in coastal Louisiana. Within the four subprovinces, there were 193 vegetation projects as of 2003. The total acreage benefited for each Subprovince is as follows: Subprovince 1 had 486 acres, Subprovince 2 had 1,004 acres, Subprovince 3 had 1,785 acres, and Subprovince 4 had 1,973 acres created, restored, and/or protected. These plantings have rehabilitated fresh, brackish, intermediate, and saline marsh, swamp, and barrier islands.

1.7.1.10 Mitigation Banks In The Louisiana Coastal Zone

Currently, the District's Regulatory Branch database indicates that there are currently 21 mitigation banks in 10 parishes within the boundaries of the “coastal zone”. These mitigation banks hold a total about 9,000 acres of swamp and bottomland hardwood forests. The total credits used or total acres planted in these mitigation banks are about 4,908 acres. There is more acreage available for sale and more opportunities for mitigation banks to be created.

1.7.1.11 Parish Coastal Wetlands Restoration Program

The Parish Coastal Wetlands Restoration Program (PCWRP), also known as the "Christmas Tree Program" is designed to encourage public involvement and participation in coastal restoration. The LDNR web site (http://www.savelawetlands.org/site/Xmas/xmas3.html) provides the following description of the PCWRP or Christmas Tree program. The Louisiana Christmas Tree Program originated from a similar erosion-control technique created in the Netherlands. In 1986, Louisiana State University scientists constructed brush fences using willow limbs and branches. Although this brush fence was effective, it required too much effort to build. In 1989, DNR/CRD constructed a prototype brush fence using Christmas trees at the La Branche

Wetlands in St. Charles Parish. Twenty-three brush fences were built and filled with 8,000 used Christmas trees obtained from local citizens. This project was successful and set the stage for the DNR/CRD Parish Coastal Wetlands Restoration Program (PCWRP), otherwise known as the Christmas Tree Program. The PCWRP expanded in 1990 to all coastal zone parishes through DNR/CRD and has now been in existence for eleven years. During this time over 40,000 linear feet, or approximately 8 miles, of brush fences have been built, with over 1,140,000 Christmas trees utilized. Jefferson Parish alone has used over 704,000 Christmas trees to fill brush fences and abandoned oil field canals.

1.7.1.12 Federal Emergency Management Agency

The Federal Emergency Management Agency (FEMA) provides aid to people and areas that have been adversely affected by presidentially declared natural disasters. Aid provided by FEMA includes vegetative plantings, beneficial use of dredged material, sand fences on barrier islands, repairing water control structures, and bank repair. As of 2003, FEMA assisted the state of Louisiana after several hurricanes, tropical storms, and flooding events with 8 projects, which benefited over 5,379 acres.

1.7.1.13 Non-Governmental Agencies (NGOs)

Non-governmental agencies (NGOs) and other private interests include: private landowners, family estates, corporations, non-profit organizations, environmental organizations such as Ducks Unlimited, and academic institutions. Aside from the general recognition of a few conservation organizations restoration efforts, a comprehensive accounting of the various NGO restoration activities in coastal Louisiana is lacking. Examples of public and private parties involved in wetlands preservation or restoration activities in coastal Louisiana include: Coastal America, Corporate Wetlands Restoration Partnership, Gulf Coast Joint Venture, Audubon Society, National Fish and Wildlife Foundation, Nature Conservancy, National Wildlife Federation, the North American Wetlands Conservation Act (NAWCA), administered by the USFWS; and the Wisner Foundation, in a community-based partnership with the University of New Orleans, Morris P. Hebert, Incorporated, the Barataria-Terrebonne Estuary Program, Restore America's Estuaries Program, Chevron and the Federal government. A more detailed accounting of these restoration activities is presented in section 4.23.1 Federal, State, Local and Private Restoration Efforts.

1.7.2 Lessons Learned and Opportunities for the LCA Study

The resources of the Mississippi River system remain available to contribute to the restoration of the coastal Louisiana ecosystem. The Federal Government and State of Louisiana have been conducting ecosystem restoration efforts for the past 14 years under the CWPPRA. In addition, the scientific community in Louisiana is recognized internationally for their expertise in climate and wetland research. The lessons learned and extensive experience gained from past restoration and research efforts have been applied in the LCA Study and can continue to be applied in a systematic way to develop and implement a coast wide plan for addressing the land loss problem and critical needs facing coastal Louisiana. Opportunities for ecosystem restoration include:

- Freshwater Re-introductions - Diverting water from the Mississippi River into hydrologic basins can 1) nourish existing marshes to increase their productivity and build wetlands in areas of open water, 2) potentially reduce the extent of the hypoxic zone in the gulf, 3) help satisfy the need for maintaining salinity gradients that correspond to the diversity of vegetative habitat, and 4) reintroduce and distribute sediments and nutrients throughout the ecosystem;
- Barrier island restoration, through placement of sand from offshore sources or the Mississippi River, could sustain these geomorphic structures, which would provide additional protection from hurricane storm surges and protect the ecology of estuarine bays and marshes by reducing gulf influences, as well as protect nationally important water bird nesting areas;
- Hydrologic modification, such as degrading excavated dredged material banks, can help restore salinity and marsh inundation patterns and provide fishery access in previously unavailable habitats; and
- The dedicated use of sediment material from dedicated or maintenance dredging (e.g. beneficial use) to create a marsh platform can create large amounts of coastal habitat quickly. Additionally, these techniques can be applied in combination to produce synergistic effects while minimizing disruptions to the surrounding ecology and economy (e.g., dedicated dredging in conjunction with a small river diversion to increase the sustainability of the created marsh).

By applying ecologically sound principles and restoration methods developed in recent years, and through improved understanding of coastal system processes and ecosystem responses to restoration projects, there is an opportunity available for Louisiana and the Nation to reverse the current trend of land loss and move the LCA ecosystem toward a sustainable future.

1.7.2.1 Freshwater and Sediment Diversions

There is an opportunity to use riverine resources, such as freshwater, sediment, and nutrients, transported down the Mississippi River and its distributaries to reverse coastal land loss, restore hydrologic connectivity, and improve ecosystem function. Controlled diversions into marshes with water depths averaging about five feet or less would require relatively less sediment for each acre of new land and would likely be more effective in counteracting land loss than the building of sub-deltas in relatively deep water. Mimicking crevasses through reintroductions into waters with depths of approximately 12 feet may be a practical and effective means of creating land in bays and sounds adjacent to the Mississippi River, but would require substantially more sediment for each acre of marsh created.

In creating new land, it is not desirable to completely fill the receiving water bodies. Rather, it would be more desirable to transform large lakes and bays into a series of interconnecting ponds with shallow water depths. Judicious spacing of the sub-delta lobes would substantially increase the land/water interface, which is more attractive to marsh and estuarine life forms. The introduction of sediment should be carried out periodically. This would allow plants and animals to enter and establish themselves in the newly made areas shortly after the land is formed.

In addition to freshwater diversions, hydrologic restoration can also be accomplished through salinity control management in areas where riverine sources are less abundant, such as in the Chenier Plain.

1.7.2.2 Beneficial Use of Dredged Materials

The beneficial use of dredged material can also reduce land loss. The U.S. Army Corps of Engineers-Mississippi Valley, New Orleans District (District) excavates an average of 70 million cubic yards (mcy) of material annually in maintenance dredging of navigation channels. A significant portion of this volume is either re-suspension or hopper dredged material, however, and is therefore not available for beneficial placement. The USACE has beneficially placed dredged material to create over 16,000 acres of land since 1985. To provide perspective, placing 60 million cubic yards of material in water bodies up to 3 feet in depth, and allowing for losses due to compaction, subsidence, and erosion, could result in the creation of 4,300 acres of marsh per year. This is approximately 28 percent of the current annual net rate of land loss.

1.7.2.3 Nearshore and Offshore Sand Resources

Barataria offshore sand resources

Identification of sand resources to support the coast wide restoration of Louisiana's barrier islands and back barrier marshes requires finding large volumes of high-quality sand and developing cost-effective delivery systems to move these materials. The recent cooperative study by the USGS, the University of New Orleans, and USACE (Kindinger et al., 2001) as part of the Barataria Feasibility Study provides such information for the offshore Barataria Basin area.

Seismic and sonar interpretations verified by geologic core samples confirm that there are several nearshore sand bodies within the Barataria offshore area that meet or exceed the minimum criteria for potential mining sites. These sand bodies potentially contain between 396 and 532 mcy of sand and can be characterized into surficial and buried sites. However, while these potential sand sources consist primarily of fine sand, a full 90 percent of the sand body areas will need almost 570 mcy of overburden removed if the entire resource is mined. Kindinger et al. (2001) recommend using the sands for barrier island shoreface restoration and the overburden to build back-barrier platforms for marsh restoration. The researchers also recommend consideration of Ship Shoal (a large clean surficial sand deposit) as an alternative resource.

Terrebonne/Timbalier offshore sand resources (Ship Shoal)

Ship Shoal, the largest submerged shoal off Louisiana, is a sand body located on the south-central Louisiana inner shelf about 9.5 mi seaward of the Isles Dernieres. Ship Shoal is approximately 31 mi long and 3-7.5 mi in width, with relief of up to 12 feet. Water depth ranges from 23-30 feet on the eastern side of the shoal to approximately 10 feet over the western reaches (Penland et al., 1986). It is composed primarily of well-sorted quartz sand, a benthic substrate not commonly found on the Louisiana inner shelf (Stone, 2000).

1.7.2.4 Availability of Coastal Wetlands to Remove Nutrients

In January 2001, the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force issued the Action Plan for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico (Action Plan). According to the Action Plan, restoring and enhancing de-nitrification and nitrogen retention in the Mississippi River Basin, including the Deltaic Plain in southeastern Louisiana, are a primary approach for reducing gulf hypoxia. Mitsch et al. (2001) also identify Mississippi River diversions as a tool for reducing gulf hypoxia, and estimate that potential nitrate reduction using diversions "is probably limited to less than 10 percent to 15 percent of total flux in the river."

Preliminary results of earlier LCA water quality modeling efforts (see appendix C Hydrodynamic and Ecological Modeling of the Main Report) along with existing literature on the subject (Mitsch et al., 2001) suggest that large-scale river diversions could have the potential to contribute significantly to the national effort to reduce hypoxia in the northern Gulf of Mexico. Because some river diversion features evaluated during plan formulation are relatively small, implementation of such projects would likely result in nutrient reductions that are small in comparison to total nutrient inputs from the Mississippi River to the gulf. Implementation of a LCA Plan would, however, provide an excellent opportunity to add to our understanding of the effectiveness of river diversions in reducing nutrient inputs from the Mississippi River to the Gulf of Mexico, while also further studying any potential adverse effects of such projects. In this way, the lessons learned from implementation of the river diversion features could facilitate large-scale river diversion projects in the future, along with the potentially significant nutrient reductions such projects might provide.

1.8 NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) REQUIREMENTS

In compliance with NEPA, this report documents the programmatic approach of the LCA Study. In an effort to reduce paperwork, integrate NEPA requirements with other environmental review and consultation requirements, and combine environmental documents with other documents, this report utilizes some concepts established by the CEQ -- adoption, incorporation by reference, and tiering.

Adoption is discussed in 40 CFR Section 1506.3. "*An agency may adopt a Federal draft or final environmental impact statement or portion thereof provided that the statement or portion thereof meets the standards for an adequate statement under these regulations."* This report adopts in its entirety or portions thereof previous NEPA documents to take advantage of lessons learned from previous Louisiana coastal wetlands restoration efforts. The document and/or portions being adopted include:

Coast 2050: Toward a Sustainable Coastal Louisiana;
Coast 2050: Toward a Sustainable Coastal Louisiana, An Executive Summary;
Coast 2050: Toward a Sustainable Coastal Louisiana, The Appendices;
(source: http://www.coast2050.gov)

Tiering is discussed in 40 CFR Section 1508.28. *"Tiering refers to coverage of general matters in broader environmental impact statements (such as national program or policy statements) with subsequent narrower statements or environmental analyses (such as regional or basin-wide program statements or ultimately site-specific statements) incorporating by reference the general discussions and concentrating solely on the issues specific to the statement subsequently prepared. . . from an environmental impact statement on a specific action at an early stage (such as need and site selection) to a supplement (which is preferred) or a subsequent statement or analysis at a later stage (such as environmental mitigation). Tiering in such cases is appropriate when it helps the lead agency to focus on the issues which are ripe for decision and exclude from consideration issues already decided or not yet ripe."* This statement will serve as a programmatic analysis for restoration efforts that will concentrate on coastwide, province-wide, and basin-wide issues. This statement will provide the foundation for more site-specific environmental analysis as needed at later dates.

1.9 PRIOR STUDIES, REPORTS AND EXISTING WATER RESOUCES PROJECTS

A number of studies and reports on water resources development in the study area have been prepared by the USACE, other Federal, state, and local agencies, research institutes, and individuals. Previous studies established an extensive database for the LCA Study. Historical trends and existing conditions were identified to provide insight into future conditions, help isolate the problems, and identify the most critical areas. The following studies, reports, and projects in the LCA are the most relevant to ecosystem restoration. A detailed listing of prior studies, reports, and water resources projects is contained in attachment 2.

1.9.1 The Mississippi River and Tributaries (MR&T) Project

The Mississippi River and Tributaries (MR&T) Project is a comprehensive project for flood control on the lower Mississippi River below Cape Girardeau, Missouri. The four major elements of the MR&T Project are: 1) levees for containing flood flows; 2) floodways for the passage of excess flows past critical reaches of the Mississippi River; 3) channel improvement and stabilization for stabilizing the channel in order to provide an efficient navigation alignment, increase the flood carrying capacity of the river, and protect the levee system; and 4) tributary basin improvements for major drainage and for flood control, such as dams and reservoirs, pumping plants, auxiliary channels, etc. (**figure 1-12**). The MR&T system controls and confines the river system before it reaches the coastal area. Several major outlets to the main stem of the river, which are described below, exist for the purposes of flood control during flood stages.

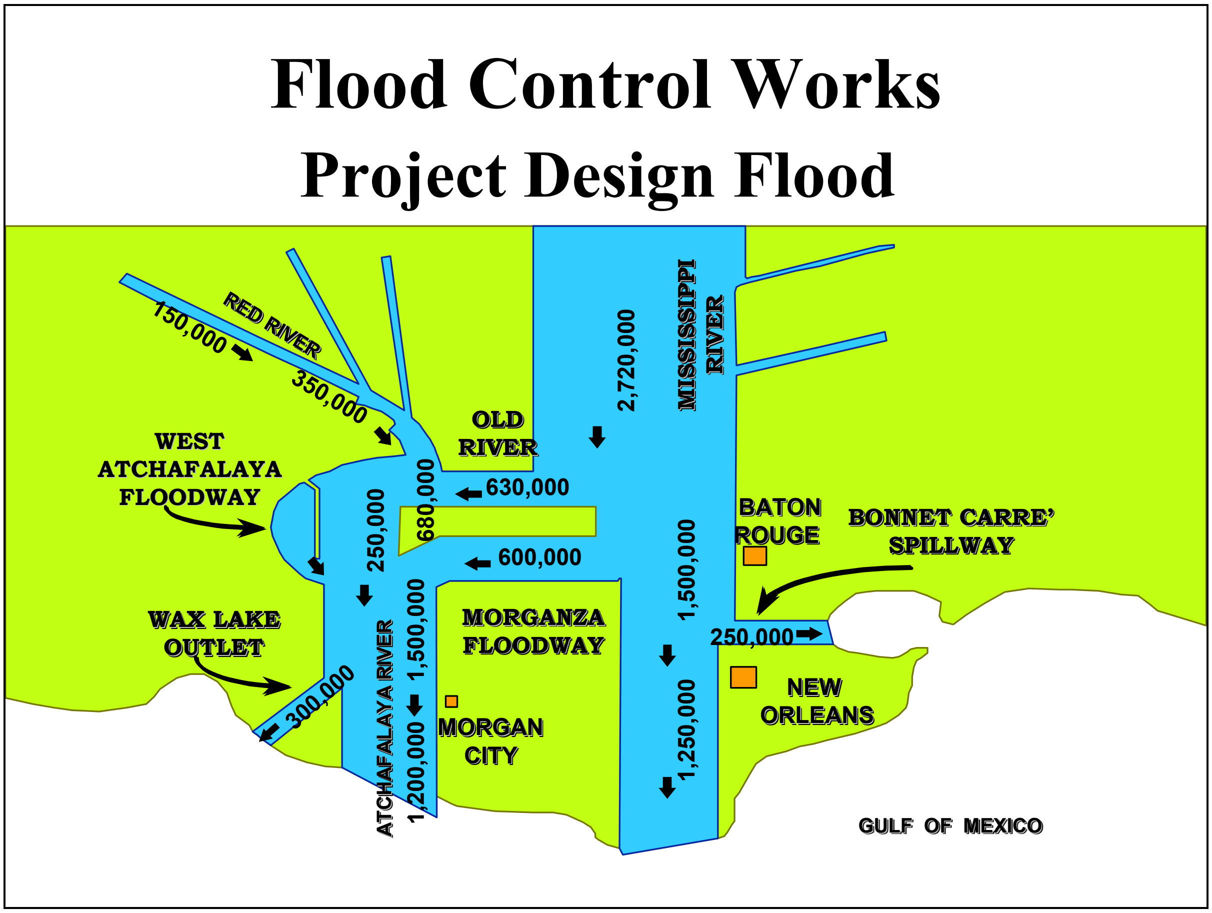

Figure 1-12. MR&T Scenario During Maximum Flood Projected Flood Conditions.

1.9.2 The Atchafalaya Basin

At the latitude of the Old River Control Complex, the MR&T Project flood totals 3,000,000 cubic feet per second (cfs) consisting of the sum of the Red River and Mississippi River flood flows. The Atchafalaya Basin is designed to convey up to one half of the project flood flows or 1,500,000 cfs. During daily operations, the Old River Control structures are regulated to maintain a 70/30 distribution between the Mississippi/Atchafalaya Rivers. In authorizing the Old River Control Complex (Flood Control Act of 1954), Congress directed that the system distribution should be maintained at the same distribution that existed in 1950 which was 70/30. During a project flood, the Old River Control Complex would divert up to 620,000 cfs from the Mississippi River to the Atchafalaya from the Morganza and West Atchafalaya Floodways.

The Morganza Floodway (located to the east of the Atchafalaya River) and the West Atchafalaya Floodway (located to the west of the river) are two floodways that can convey floodwaters into the Atchafalaya Basin during severe floods. The West Atchafalaya Floodway is controlled by a fuse plug levee at the Red River, which would overtop or be blown in the event of the project flood, thereby allowing an additional 250,000 cfs to enter the basin. The Morganza Floodway is controlled by a structure at the Mississippi River that can allow another 600,000 cfs to enter the basin in the event of the project flood.

The basin has two outlets at the southern end, which empty into Atchafalaya Bay and then the Gulf of Mexico. One outlet is the Lower Atchafalaya River, a natural outlet, while the other is a manmade outlet, the Wax Lake Outlet, which was constructed in 1941 to facilitate better conveyance of flood flows.

1.9.3 Bonnet Carre Spillway

The Bonnet Carre Spillway is another outlet that is located at the site of an old crevasse, and contains a control structure at the Mississippi River. The facility is designed to convey a maximum of 250,000 cfs of floodwaters to Lake Pontchartrain in order to relieve flood conditions downstream.

1.9.4 Caernarvon and Davis Pond Freshwater Diversion Projects

In April 1983, a report entitled, Freshwater Diversion to the Barataria and Breton Sound Basins, was prepared by the USACE. The report recommended diverting Mississippi River water into Breton Sound Basin near Caernarvon and into Barataria Basin near Davis Pond to increase habitat quality and improve fish and wildlife resources. The Caernarvon Freshwater Diversion was completed in 1991 with a design discharge of 8,000 cfs. Since its construction, the Caernarvon structure has been operated as a salinity control measure, with freshwater introductions ranging between 1,000 cfs to 10,000 cfs. The Davis Pond Freshwater Diversion was completed in 2002 with a maximum design capacity of 10,650 cfs. It is noted that a third freshwater diversion project with a maximum capacity of 30,000 cfs at Bonnet Carre was included in the 1983 report, but the project has not been constructed due to non-support by non-Federal interests.

1.9.5 The Gulf Intracoastal Waterway (GIWW)

The GIWW was authorized and began construction in the 1920s. It traces the U.S. coast along the Gulf of Mexico from Apalachee Bay near St. Marks, Florida, to the Mexican border at Brownsville, Texas. From its intersection with the Mississippi River, the waterway extends eastward for approximately 376 miles and westward for approximately 690 miles. In addition to the main stem, the GIWW includes a major alternate channel, 64 miles long, which connects Morgan City, Louisiana, to Port Allen, Louisiana. Project dimensions for the main stem channel and the alternate route are 12 ft deep and 125 ft wide, except for the reach between the Mississippi River and Mobile Bay, which is 150 ft wide. Today, portions of the GIWW are deeper and wider than the original construction dimensions. Numerous side channels and tributaries intersect both the eastern and western main stem channel, providing access to inland areas, coastal harbors, and the Gulf of Mexico.

1.9.6 Mississippi River Gulf Outlet (MRGO)

The River and Harbor Act of 1956 (PL 84-455) authorized construction of the Mississippi River Gulf Outlet (MRGO), a navigation channel that was completed and put into service in the mid-1960s. The MRGO provides deep draft navigation access to the New Orleans tidewater port area located along the upper reaches of the MRGO and the Inner Harbor Navigation Canal (IHNC), close to its junction with the Mississippi River. Today, the surface dimensions of the channel have increased beyond those of the original construction, and in some areas, the width of the channel has significantly widened as a result of erosion.

The USACE is currently investigating the feasibility of modifying the MRGO Navigation Project because of the increased cost of channel maintenance in recent years, a result of decreased channel use at maximum depths. The environmental and flood control benefits of channel modifications are also being investigated. The reevaluation study is tentatively scheduled for completion in September 2004.

1.9.7 Morganza to the Gulf

In March 2002, a feasibility report and EIS entitled Mississippi River & Tributaries - Morganza, Louisiana to the Gulf of Mexico --Hurricane Protection was prepared by the USACE. The recommended plan proposed a series of flood protection measures such as:

- The construction of approximately 72 miles of levee south of Houma;
- The construction of nine gate structures in various waterways and three floodgates in the GIWW;
- The construction of a lock structure and floodgate complex for the Houma Navigation Canal (HNC); and
- The construction and operation of new and replacement fish and wildlife structures in selected locations in order to maintain tidal exchange.

The area to be protected by the levee system is a former major delta from a previous course of the Mississippi River. As in other locations in south Louisiana, urban and agricultural development has occurred along the banks of the remnant ridges of the delta. Therefore, conveyance of freshwater via the Mississippi River through these remnant channels is not practical. However, the close proximity of the area to the Atchafalaya Basin offers other options of freshwater distribution. The GIWW is linked to the Atchafalaya Basin and conveys water eastward to the area. The HNC intercepts these flows before they reach the area of need and conveys them efficiently to the Gulf of Mexico. If authorized, and with the levee system and water control structures in place, the Atchafalaya River flows can be managed and distributed across the area.

1.9.8 Third Delta

In June 1999, a report entitled The Third Delta Conveyance Channel Project was completed by S. M. Gagliano and J. L. van Beek. The primary concept of the "Third Delta Conveyance Channel" is to re-establish the natural processes of Mississippi River land building on a large scale as a fundamental approach to achieving sustainable restoration in coastal Louisiana. The report discusses reintroduction of Mississippi River water and sediment in a manner that mimics natural processes. The implementation of a Third Delta would likely target wetlands in western Barataria Basin and eastern Terrebonne Basin. The LDNR is currently undertaking a reconnaissance-level study to evaluate the feasibility of constructing the Third Delta as proposed, and also to define and evaluate alternatives to the original concept that may also achieve the desired results. This study is expected to be complete by December 2004.